DEVELOPMENT OF VEGETATION AND DIGITAL IMAGE DATABASES FOR APPOMATTOX COURT HOUSE NATIONAL HISTORICAL PARK

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Table of Contents

Summary iii

Introduction 1

Study Area 1

Methods 2

- Aerial Photography 2
- Constructing the Orthophoto Mosaic 2
- Vegetation Classification 2
- Accuracy Assessment 3

Results and Discussion 4

- Orthophoto Mosaic 4
- Vegetation Map 4
- Deliverables 5

Appendix 7

Summary

The goal of this project was to develop a digital orthophoto mosaic and a digital geospatial vegetation database for Appomattox Court House National Historical Park (APCO). For this project, vegetation was classified to the formation level using the National Vegetation Classification System developed by The Nature Conservancy and the network of Natural Heritage Programs.

Creation of the orthophoto mosaic and the vegetation database involved:

- Scanning, orthorectifying, and mosaicking 1:6,000 scale color infrared aerial photography provided by the National Park Service (NPS);
- Developing a list of vegetation formations for APCO from The Nature Conservancy's Terrestrial Vegetation of the United States;
- Classifying aerial photographs provided by the NPS to the formation level using the National Vegetation Classification System;
- Assessing positional accuracy of the orthophoto mosaic and thematic accuracy of the digital vegetation database; and
- Developing FGDC compliant metadata for both databases.

This report describes the methods and materials for performing these tasks and includes the results of the accuracy assessments. More detailed descriptions of each component of the project are contained in the Master's thesis, "Development of a Digital Protocol for Vegetation Mapping," by Melani Hix Harrell that is appended to this report.

DEVELOPMENT OF VEGETATION AND DIGITAL IMAGE DATABASES FOR APPOMATTOX COURT HOUSE NATIONAL HISTORICAL PARK

FINAL TECHNICAL REPORT

Introduction

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Study Area

Appomattox Court House National Historical Park is located in the Piedmont Plateau physiographic region in south central Virginia. Within the park, elevations range from 460 to 1,151 feet above sea level. Much of the park is drained by the Appomattox River, a tributary of the James River, which traverses the northern portion of the park. The average annual temperature is 56.7 ° Fahrenheit, average annual rainfall is 44 inches, average annual snowfall totals 16.9 inches, and prevailing winds in the park area are from the south and southwest. Vegetation in the park is shaped by these environmental factors, along with occasional high winds and ice storms.

Methods

Aerial Photography

Aerial photography for this project was flown by Air Photographics, Incorporated on December 18, 2000 in leaf-off conditions. The photography includes 50 color infrared photographs at a scale of 1:6,000 flown along five flight lines. Three flight lines ran west to east and two ran east to west.

We scanned the photographs with an EPSON Expression 836 XL desktop scanner using Adobe Photoshop 5.0 software at a resolution of 600 dots per inch. The scanned images were saved as Tagged-Image File Format files that were subsequently converted to ERDAS Imagine image files.

Constructing the Orthophoto Mosaic

Orthorectification, the process of removing radial tilt and relief distortion from aerial photographs and the first step in creating a photo mosaic, was performed using ERDAS Orthobase software. We used four USGS color infrared digital orthophoto quarter quadrangles (DOQQs) to provide the X- and Y-coordinate references for orthorectifying the scanned photography. The four DOQQs were mosaicked into a single image and projected to match existing park data layers.

A digital elevation model (DEM) obtained from the USGS National Seamless Elevation dataset was used to provide the elevation data required for orthorectification. The DEM was reprojected and resampled from 30-meter to 10-meter pixel resolution.

Aerial triangulation was performed using the mosaicked DOQQs, the DEM, and 230 ground control points and yielded errors of 0.906 meters in the X-coordinate direction, 1.296 meters in the Y-coordinate direction, and 3.506 meters vertically. Orthophotos for each of the 50 scanned air photos were generated in Orthobase using bilinear interpolation.

The orthophotos were mosaicked using ERDAS Imagine software and the resulting orthophoto mosaic was compressed using Multi-Resolution Seamless Image Database (MrSID) software. The compressed image is faster and easier to manipulate in ArcView, the GIS software used at APCO.

Vegetation Classification

The process of delineating formation-level vegetation classes was performed on-screen using ERDAS Stereo Analyst software. Before starting the on-screen classification, the interpreter reviewed and classified DOQQs of the APCO area and compiled a list of possible vegetation formations and alliances for the area. This list, which was reviewed and edited by Gary Fleming of the Virginia Natural Heritage Program, served as a guide during the preliminary vegetation classification process.

Air photo interpretation and on-screen delineation of vegetation polygons was performed using an ERDAS Stereo Analyst workstation equipped with a color monitor with a high refresh rate and an emitter box affixed to the top of the monitor. The interpreter wears a pair of battery-powered goggles that flash 120 times per second. Emitter waves strike the goggles and, with the high refresh rate of the monitor, allow the interpreter to view a photo pair on-screen in stereo. The interpreter used a crosshair cursor manipulated by the mouse to delineate areas of homogeneous vegetation greater than one-half acre in size. After all the stereo pairs were examined and delineated, an ArcView shapefile of vegetation polygons was created. The final shapefile contains 399 polygons: 309 vegetation polygons and 90 polygons representing non-vegetated areas such as roads, barren land, etc. The interpreter then labeled each vegetation polygon with a National Vegetation Classification System formation class and with a "possible alliance" class. The "possible alliance" classification was based on details visible to the interpreter on the stereo pairs and on a 1986 Forest Management Plan prepared by Virginia Polytechnic Institute. The 90 non-vegetated polygons were classified using levels I and II of Anderson's land-use and land-cover classification system for remote sensor data.

Accuracy Assessment

Positional accuracy of the orthophoto mosaic is based on data collected with a Trimble ProXRS GPS unit at 39 points within the park. The total number of real-time corrected points after data download was 37; differential correction was performed using Trimble Pathfinder version 2.70 software and two additional points were corrected during post-processing. Coordinates for these points were compared to the coordinates taken from the orthophoto mosaic to determine the positional accuracy of the mosaic.

Thematic accuracy of the vegetation map was assessed by visiting a sample of plots within the study area, recording the vegetation class (formation and alliance) of each plot, and comparing these data with corresponding data from the on-screen classification. A stratified random sample of 203 plots was selected according to USGS-NPS sampling guidelines and fieldwork was carried out using a Trimble ProXRS GPS unit. In the field, a USGS-NPS Vegetation Mapping Program Accuracy Assessment Form was completed for 196 of the 203 sample plots. Six of the seven plots that were not visited because of time constraints were located on private property outside the park boundary. Elevation, aspect, major species present by strata, and alliance class were recorded for each plot.

Results and Discussion

Orthophoto Mosaic

Positional accuracy of the orthophoto mosaic meets Class 1 National Map Accuracy Standards in the X-coordinate direction and Class 2 National Map Accuracy Standards in the Y-coordinate direction with root mean square errors of 0.603 meters and 2.415 meters, respectively.

It should be noted that because of the agricultural and forested nature of the park's land cover, it was not possible to find as many well defined landmarks for performing accuracy assessment as would have been desirable. In addition, most of the 39 points used for assessing positional accuracy are located along local roads and are not distributed as widely as would have been desirable.

Vegetation Map

Initial thematic accuracy of the vegetation map was 77.55 percent: 152 of the 196 sample polygons were correctly classified and 44 polygons were incorrectly classified. Based on the accuracy assessment fieldwork, data for the 44 initially misclassified polygons were corrected. Assuming that the 196 surveyed polygons are now correctly classified and that 77.55 percent of the remaining 203 polygons are correctly classified, the thematic accuracy of the final formation level vegetation map is 88.70 percent.

The most prevalent classification errors included:

- Classifying Lowland or Submontane Cold-deciduous Forest formations as Temporarily Flooded Cold-deciduous Forest

  Forested areas around the North Branch of the Appomattox River and Plain Run Branch that appeared relatively flat when viewed in stereo on the screen were incorrectly classified as Temporarily Flooded Cold-deciduous Forest.

- Classifying natural pine forests as planted pine forests

  Spectral inconsistency among the aerial photos was the main reason for misclassifying natural stands as planted stands.

In addition, omission errors that occurred in six vegetation classes are likely due to the five-month time lag between acquiring and interpreting the aerial photography. We believe that in a number of cases, vegetation that did not appear on the photographs to be tall enough and/or dense enough to classify in one of the shrubland or forest formation classes had grown enough, by the time of the accuracy assessment fieldwork, to be classified into one of those classes.

Deliverables

The following digital products, on a set of three compact discs, have been delivered to APCO and to Beth Johnson, Inventory and Monitoring Coordinator for the NPS Northeast Region:

1. Digital orthophoto image of APCO and the surrounding area in ERDAS Orthobase format and FGDC compliant metadata

2. Digital orthophoto image of APCO and the surrounding area in MrSID compressed format and FGDC compliant metadata

3. Digital geospatial formation-level vegetation database for APCO and FGDC compliant metadata

4. The mosaicked DOQQs that were used to create the orthophoto image

5. The DEM that was used to create the orthophoto image

Appendix

DEVELOPMENT OF A DIGITAL PROTOCOL FOR VEGETATION MAPPING

BY

MELANI HIX HARRELL

A THESIS SUBMITTED TO THE GRADUATE FACULTY OF
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ABSTRACT

HARRELL, MELANI HIX. Development of a digital protocol for vegetation mapping. (Under the direction of Dr. Hugh Devine)

Softcopy photogrammetry has proven useful to reduce mapping time with aerial photography and aids in producing a digital product that is easily transferable over other electronic media. This study brings together computer stereo viewing with scanned aerial photos in a GIS to produce a fully digital protocol for mapping vegetation to the formation level. Erdas Imagine was used to generate digital images from aerial photos, Erdas Orthobase was applied to orthorectify the images through a joint triangulation solution for 42 photos, and Erdas StereoAnalyst provided on screen stereo viewing for vegetation delineation. Vegetation polygons were then classified using the National Vegetation Classification System formations in ArcView 3.2, and a thematic accuracy assessment was carried out on the vegetation map using the USGS-NPS standards. A positional accuracy assessment was conducted on the photo mosaic produced from the orthorectified images. Thematic accuracy was 77.55% initially, and the revised map had an 88.70% thematic accuracy. Positionally, the photo mosaic had Class 1 positional accuracy along the X-coordinate with 0.603 meters RMSE and had Class 2 accuracy along the Y-coordinate with 2.415 meters RMSE. A protocol using entirely digital methods was produced with the software cited that meets the formation level USGS-NPS vegetation mapping standards.

TABLE OF CONTENTS

LIST OF TABLES IX

LIST OF FIGURES X

1. INTRODUCTION 1

1.1 APPOMATTOX COURT HOUSE NATIONAL HISTORICAL PARK 1
1.2 STUDY AREA 2
1.3 THE APPOMATTOX COURT HOUSE NATIONAL HISTORICAL PARK MAPPING PROJECT 3
1.3.1 Creating a General Management Plan (GMP) 5
1.3.2 Current Park Inventory 6

2. LITERATURE REVIEW 9

2.1 THE NATIONAL VEGETATION CLASSIFICATION SYSTEM 9
2.2 VEGETATION MAPPING 10
2.2.1 Existing USGS-NPS Vegetation Maps 10
2.2.2 Past Users of the NVCS with Remote Sensing 14
2.2.3 Digital Mapping Methods 17

2. OBJECTIVES 20

4. MATERIALS AND METHODS 21

4.1 OBTAINING DIGITAL DATA 21
4.1.1 Aerial Photography 21
4.1.2 Digital Orthorectified Quarter-quadrangles 22
4.1.3 Digital Elevation Models 23
4.2 ORTHORECTIFICATION 23
4.3 PHOTO MOSAIC CONSTRUCTION 28
4.4 PHOTOGRAPHY CLASSIFICATION WITH STEREO MODELING 30
4.5 ACCURACY ASSESSMENT 33

5. RESULTS 38

5.1 ORTHOPHOTO MOSAIC 38
5.2 FORMATION VEGETATION MAP 41

6. DISCUSSION 49

6.1 EVALUATION OF MAPPING PROCESS 49
6.1.1 Ground Control 49
6.1.2 Mapping Time 49
6.2 ACCURACY 51
6.2.1 Time Lapse 51
6.2.2 GPS 51

6.2.3 Map Registration Error *52*
6.2.4 Locating Landmarks for Positional Accuracy Assessment *53*
6.3 MISCLASSIFICATIONS 54

8. RECOMMENDATIONS 57

8.1 FUTURE STUDY 57
8.2 FURTHER NVCS DEVELOPMENT 58
8.3 EMPLOYING ANCILLARY DATA 58

9. REFERENCES 60

APPENDIX A. NSE DEM PREPARATION COMMANDS IN ARCINFO GRID 66

APPENDIX B. VEGETATION LINE SHAPE FILE CONVERSION TO POLYGON SHAPE FILE 67

APPENDIX C. ERDAS ORTHOBASE PHOTO MOSAIC METADATA 68

APPENDIX D. FORMATION MAP METADATA 74

APPENDIX E. MRSID PHOTO MOSAIC METADATA 83

APPENDIX F. NVCS FORMATIONS, ALLIANCES, AND DESCRIPTIONS IDENTIFIED AT APPOMATTOX COURT HOUSE NATIONAL HISTORICAL PARK 90

APPENDIX G. ANDERSON LEVEL I AND II CLASSES IDENTIFIED AT APPOMATTOX COURT HOUSE NATIONAL HISTORICAL PARK 98

APPENDIX H. SAMPLING SCRIPT WRITTEN FOR USE WITH USGS-NPS VEGETATION MAPPING ACCURACY ASSESSMENT BY FRANK KOCH 99

APPENDIX I. THEMATIC ACCURACY ASSESSMENT SAMPLING SCHEME 105

APPENDIX J. CAMERA CALIBRATION REPORT 107

APPENDIX K. THEMATIC ACCURACY DATA 111

APPENDIX L. POSITIONAL ACCURACY DATA 113

APPENDIX M. PRELIMINARY FORMATION AND ALLIANCE LIST FOR THE ACHNHP MAPPING PROJECT 114

APPENDIX N. USGS-NPS VEGETATION MAPPING PROGRAM ACCURACY ASSESSMENT FORM 116

List of Tables

TABLE 1. COMPARTMENT DESIGNATIONS FOR VPI FOREST MANAGEMENT PLAN. 8

TABLE 2. NVCS HIERARCHICAL CLASSES. 9

TABLE 3. PARK SIZES INDICATING SAMPLING APPROACH USED. 11

TABLE 4. AERIAL TRIANGULATION PARAMETERS. 28

TABLE 5. NUMBER OF POLYGONS IN EACH FORMATION, HECTARES, AND ACRES FOR THE MAP CLASSES. 34

TABLE 6. POSITIONAL ACCURACY CHI-SQUARED STATISTICS FOR THE PHOTO MOSAIC.................. 40

TABLE 7. THEMATIC ACCURACY ASSESSMENT ERROR MATRIX. 43

TABLE 8. PRODUCER'S AND USER'S ACCURACY. 46

TABLE 9. EXTERIOR ORIENTATION PARAMETERS FOR EACH IMAGE AS ESTIMATED BY AERIAL TRIANGULATION. 64

List of Figures

Figure 1. Park location in central Virginia. 1

Figure 2. 1986 VPI Forest Management Plan 8

Figure 3. Wind Cave National Park Vegetation Map. 13

Figure 4. Point Measurement Tool window. 26

Figure 5. Photo mosaic definition in Erdas Imagine Mosaic Tool. 30

Figure 6. Stereo Analyst system set up with user wearing goggles. 31

Figure 7. The Stereo Analyst digitizing interface. 33

Figure 8. Thematic accuracy points assigned by script on the orthophoto mosaic. 35

Figure 9. Positional accuracy point distribution on the MrSID photo mosaic. 38

Figure 10. Final photo mosaic with the park boundary. 41

Figure 11. Revised Appomattox Court House formation vegetation map with legend. 48

Figure 12. Planted pine compared to natural pine in aerial imagery. 54

1. Introduction

1.1 Appomattox Court House National Historical Park

In central Virginia, Appomattox Court House is located in Appomattox County, Virginia, in the Piedmont Plateau physiographic reason near Appomattox village. The village is the county seat for the county.

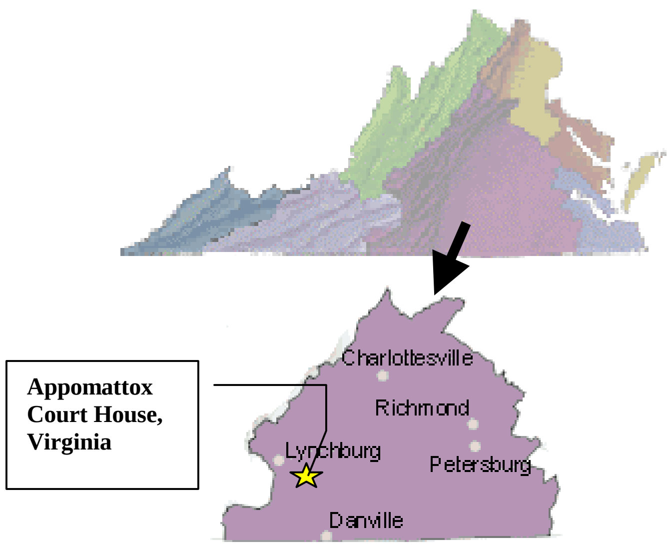

Figure 1. Park location in central Virginia.

“Appamatuck”, the Indian name for this area along a tributary to the James River, gave the village its name. Clover Hill was the original village name. The current main buildings, including the courthouse, were constructed in the late 1840s. By the Civil War outbreak, Clover Hill came to be known as Appomattox Court House. The town became famous on April 10, 1865, when Robert E. Lee’s retreating Army of Northern Virginia was surrounded by Union troops on the ridge northwest of the village. Lee met Ulysses S. Grant in Appomattox Court

House, surrendering his army, and marked the eventual end of the remaining Confederate resistance.

The village of Appomattox Court House was abandoned in the early 1890s. Many residents moved two miles to the railroad station, the location of present-day Appomattox village. Most of the Appomattox Court House buildings stood empty until the NPS restored them for park use. The village abandonment preserved the original structures. Designated as a national park in 1954, Appomattox Court House National Historical Park hosts approximately 200,000 visitors per year.

1.2 Study Area

Elevations in the park range from 460 to 1,151 feet above sea level. The Appomattox River, a tributary to the James River, drains the park and travels through the northern park area. The average annual temperature is 56.7° Fahrenheit, average annual rainfall is 44 inches, and average annual snowfall totals 16.9 inches. These environmental factors along with occasional high winds and ice storms shape the area vegetation. Prevailing winds for the park area are from the south and southwest, and the local residents describe the climate as “moderate”. Forest and agricultural practices support the majority of the approximately 13,000 citizens of the village and county. These land uses surround Appomattox Court House park boundary, not presenting any immediate threat of development to the park cultural or natural resources. Planted *Pinus taeda*, natural *Pinus virginiana*, and natural *Pinus echinata* dominate the evergreen forest species, and hardwood forests are characterized by elm-ash-cottonwood, oak-pine, and oak-hickory (Town of Appomattox, not dated).

This park currently has vegetation that matches many National Vegetation Classification System (NVCS) alliance types, the classification scheme appointed by the United States Geological Survey-National Park Service (USGS-NPS) Vegetation Mapping Program Standards to be used for map production. Few significant invasive alliances were identified in this study. Six invasive species were recorded in the floristic survey completed last year (Lund and Rawinski, 2000). Current fieldwork by botanist Nancy Cowden of Lynchburg College suggests that more invasive species may be present, but not in great number.

1.3 The Appomattox Court House National Historical Park Mapping Project

The NPS Inventory and Monitoring program, in conjunction with the USGS Biological Resources Division, recognized the need in 1994 to map the vegetation present on Park Service lands throughout the nation. The vegetation maps would provide a baseline inventory to provide support for NPS Resource Management and promote vegetation-related research for both NPS and USGS (The Nature Conservancy and Environmental Systems and Research Institute, 1994). These inventories also aid in monitoring land fragmentation that impacts the park units, especially in smaller Southeastern NPS units such as Appomattox Court House.

With the new availability of the NVCS, developed by The Nature Conservancy (TNC) and the National Heritage Program (NHP), mapping US lands now has a standard national classification system. This system provides a common language for recording vegetation abundance and change nationwide. This system will help with the integrated study of vegetation types and environmental and ecological processes across the landscape (The Nature Conservancy and Environmental Systems and Research Institute, 1994). The USGS-NPS Vegetation Mapping

Program's assessment goal is to classify, describe, and map vegetation communities in more than 250 national parks (USGS [1], not dated).

The NPS approached the Center for Earth Observation (CEO) of North Carolina State University (NCSU) with a proposal to complete a digital vegetation map for Appomattox Court House National Historical Park in August 2000. The mapping objective was to digitally record Appomattox Court House's vegetation as NVCS formations using current aerial photography. This digital layer would also be compatible with other geographic information system (GIS) data layers currently used by Appomattox.

The Federal Geographic Data Committee (FGDC) coordinates the development of the National Spatial Data Infrastructure (NSDI). The NSDI sets the policies, standards, and procedures for organizations to cooperatively produce and share geographic data (FGDC, not dated). These FGDC Vegetation and Information Standards insure and support the use of a consistent classification system allowing national uniform vegetation statistics (FGDC, 1997). An important mandate of the USGS-NPS Vegetation Mapping Program in line with FGDC standards is the consistent capture and classification of vegetation types using photo interpretation and field sampling methodologies (Aerial Information Systems, 1998). The NVCS provides the uniform system for mapping vegetation. NVCS formation level mapping can be completed successfully with minimal fieldwork using aerial photography (FGDC, 1997). Aerial photography provides vegetation cover data for mapping, which ground truthing must accompany (FGDC, 1997). The USGS-NPS Vegetation Mapping guidelines and National Map Accuracy Standards (NMAS) must be met to produce a usable product for the park and NPS.

A digital, formation level map is producible using the scale of photography flown for this study (1:6,000) according to Koch (Koch, 2001). Research that produced digital formation level vegetation map was collected, and a new protocol was proposed for this study (Millinor, 2000; Koch, 2001). The first objective for Appomattox Court House was a digital, formation level vegetation map of the park unit and its surrounding area from the available color-infrared (CIR) imagery and consistent with park GIS layers. The second study objective was developing the fully digital process used to create this vegetation map.

1.3.1 Creating a General Management Plan (GMP)

All national park units are required to produce a management plan for maintaining and planning park property. To begin the GMP process, a park must have an understanding of its land and vegetation resources, cultural importance, and current or future activities. The formation level vegetation map will provide some of this information. Possible impacts at Appomattox Court House include development along the boundary, pests in pine forests, and increasing numbers of visitors per year.

Though the purpose of the Appomattox Court House park vegetation mapping is to produce a vegetation map, a photo mosaic of the park is produced as well. The mosaic gives a visual assessment of park holdings, and will serve as a base map for current and future planning. Actual locations of water, tree stands, and mowed fields on the mosaic give the user a "birds-eye" perspective of park holdings.

The vegetation map will be one of the park manager's most versatile tools for GMP development, including information on the possibilities and limitations of more intensive forms of land use (Küchler, 1967). The large amount of mowed grass in the park maintained for cultural or utility value can be monitored through use of the digital vegetation map. The cultural value of non-forested land maintained by mowing at Appomattox Court House is high because the majority of this land was cleared for farming at the time of the Civil War. Attention to historic cultural landscapes helps to create a sense of Virginia at the time of Lee's surrender.

Other uses of the vegetation data for the GMP are trail management, wildlife habitat tracking, and fire prevention. Several history trails provide access to fields and forests around Civil War homesteads and sites associated with the Army of Northern Virginia's surrender, and the vegetation map will facilitate planning and managing these. Habitat areas for black bears, wild turkey, and other native species occurring at Appomattox Court House can be noted and marked for habitat development or visitor protection. Developing a fire management protocol that recognizes areas with abundant wind throw and other fire hazards and a protocol to manage these areas can be accomplished using the aerial leaf-off aerial photography from this project.

1.3.2 Current Park Inventory

No formal land-cover inventory has been conducted for parkland resources except for a forest stand map produced in conjunction with Virginia Polytechnical Institute's (VPI) 1986 Forest Management Plan (Figure 2, descriptions in Table 1; Hamilton, 1986). VPI's plan primarily focused on management of tree stands with suggested management strategies for each homogenous type delineated on the ground with no treatment of developed or grass-covered areas. An ancillary product produced from this vegetation map was a record of developed land, roads, waters, and agricultural fields that fall within and along the park boundary.

This study will provide Appomattox Court House with an overall vegetation cover type inventory and the number of acres each type occupies. A measure of the wetlands that are present within the park boundary with be supplied through the formation and alliance determinations. Wet area types were not addressed by the 1986 study (Figure 2, Table 1), and

380 acres have been added to the park in 1995 to bring total park acres to 1,743. Measures of evergreen and deciduous formations and human impacted acres will also be a result of the vegetation map.

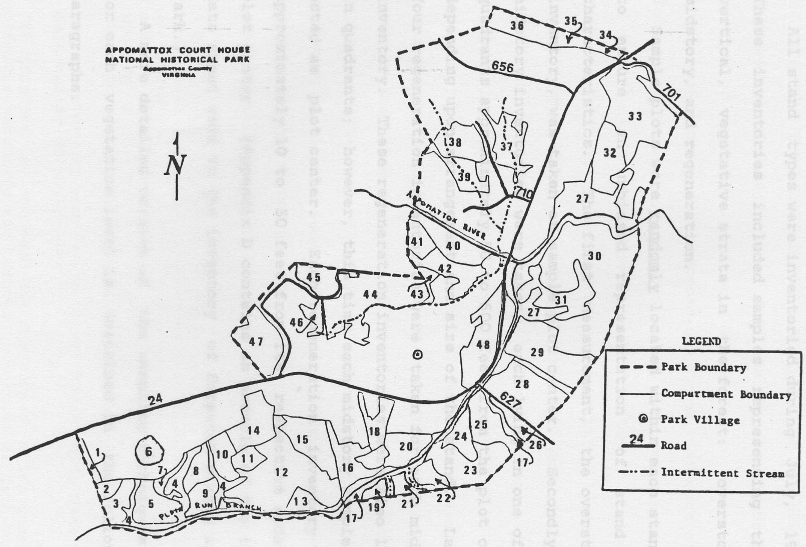

Figure 4: Compartment map for the Appomattox Court House National Historical Park, Appomattox, Virginia.

Figure 2. 1986 VPI Forest Management Plan.

Table 1. Compartment designations for VPI Forest Management Plan.

Compartment	Stand Type	Acreage
1	Pine (11- to 30-year-old)	3
2	Pine (31- to 50-year-old)	3
3	Pine (50+ year old)	8
4	Bottomland hardwood	31
5	Pine (50+ year old)	13
6	Grazed Virginia pine-Upland hardwood	5
7	Virginia pine-Upland hardwood	4
8	Virginia pine-Upland hardwood	7
9	Pine (50+ year old)	8
10	Pine (50+ year old)	8
11	Pine (31- to 50-year-old)	5
12	Pine (50+ year old)	47
13	Pine (1- to 10-year-old)	5
14	White oak-Black oak	16
15	Virginia pine-Upland hardwood	17
16	White oak-Black oak	13
17	Bottomland hardwood	22
18	Grazed Red maple-Mixed hardwood	9
19	Pine (50+ year old)	3
20	Pine (31- to 50-year-old)	11
21	Pine (50+ year old)	3
22	Pine (50+ year old)	6
23	White oak-Chestnut oak-Black oak	23
24	Pine (50+ year old)	8
25	Virginia pine-Upland hardwood	14
26	Pine (50+ year old)	5
27	Bottomland hardwood	54
28	Pine (50+ year old)	27
29	Pine (50+ year old)	28
30	White oak-Black oak	72
31	Virginia pine-Upland hardwood	17
32	Pine (31- to 50-year-old)	16
33	White oak-Chestnut oak-Black oak	36
34	Pine (1- to 10-year-old)	3
35	Pine (1- to 10-year-old)	4
36	Young Mixed Conifer-Hardwood	13
37	Grazed Red maple-Mixed hardwood	14
38	Pine (11- to 30-year-old)	13
39	Young Mixed Conifer-Hardwood	10
40	Bottomland hardwood	19
41	White oak-Black oak	7
42	Pine (31- to 50-year-old)	14
43	White oak-Black oak	3
44	Pine (31- to 50-year-old)	35
45	Pine (31- to 50-year-old)	9
46	Young Mixed Conifer-Hardwood	4
47	White oak-Chestnut oak-Black oak	19
48	Young Mixed Conifer-Hardwood	21

2. Literature Review

2.1 The National Vegetation Classification System

The NVCS system based on vegetation physiognomy describes biological and ecological patterns across the landscape (Grossman *et al.*, 1998). Collaborators included the Association for Biodiversity Information (ABI), TNC, and NHP in conjunction with the Vegetation Panel of the Ecological Society of America and the Federal Geographic Data Committee. Both physiognomic and floristic classes comprise the NVCS framework to facilitate mapping at a variety of levels.

The five levels of physiognomy in the NVCS are class, subclass, group, subgroup, and formation. Two floristic levels are recognized below formation, the alliance and association. Class is based on vegetation height and relative percentage of cover of dominant life forms, while subclass divides these by leaf phenology (e.g., deciduous forest, evergreen woodland, mixed evergreen-cold deciduous woodland). The group uses leaf structure, and the subgroup differentiates between planted and cultivated vegetation and natural vegetation.

Table 2. NVCS hierarchical classes.

The U.S. National Vegetation Classification System Hierarchy			
	Level	**Primary Basis for Classification**	**Example**
Physiognomic	**Class**	Growth form and structure of vegetation	Woodland
	Subclass	Growth form characteristics, e.g., leaf phenology	Deciduous Woodland
	Group	Leaf types, corresponding to climate	Cold-deciduous Woodland
	Subgroup	Relative human impact (natural/semi-natural, or cultural)	Natural/Semi-natural
	Formation	Additional physiognomic and environmental factors, including hydrology	Temporarily Flooded Cold-deciduous Woodland
Floristic	**Alliance**	Dominant/diagnostic species of uppermost or dominant stratum	*Populus deltoides* Temporarily Flooded Woodland Alliance
	Association	Additional dominant/diagnostic species from any strata	*Populus deltoides* - (*Salix amygdaloides*) / *Salix exigua* Woodland

Formations are groups of species that occur under the same environmental factors and share structural similarities. Formations found at Appomattox Court House are evergreen rounded-crown needle-leaved forest and lowland or submontane cold-deciduous forest. The evergreen rounded-crown needle-leaved formation is characterized almost completely by the *Pinus virginia* forest alliance at Appomattox. Alliances characterize the species that dominate or co-dominate the uppermost strata. In contrast, a variety of alliances make up the lowland or submontane cold-deciduous formation, such as *Fagus grandifolia – Quercus alba* forest alliance, the *Quercus alba – Quercus* (*falcata*, *stellata*) forest alliance, and the *Quercus alba* – (*Quercus rubra*, *Carya* species) forest alliance. Associations, the other floristic level, were not used to describe vegetation at Appomattox Court House.

2.2 Vegetation Mapping

2.2.1 Existing USGS-NPS Vegetation Maps

The USGS-NPS Vegetation Mapping Program standards must be fulfilled for an NPS unit vegetation map to be usable for the park for general management plan (GMP) purposes. Nationally defined standards of the program include:

- The federal standard for vegetation classification is the NVCS
- Metadata files that meet the FGDC metadata standard will be created for each spatial data set
- The spatial database will have an accuracy horizontally corresponding to the NMAS at the 1:24,000 scale

Program defined standards include:

- Each vegetation map class will meet or exceed 80% thematic accuracy at the 90% confidence level
- The minimum mapping unit is 0.5 hectares

With standards in place, procedures of collecting data, classifying the data, and assessing the classification for accuracy had to be developed. To begin procedure development, parks were chosen based on unit size to represent each park size class (see Table 3 for park size classes). Prototype parks included Fort Laramie National Historic Site, Scotts Bluff National Monument, Tuzigoot National Monument, Agate Fossil Beds National Monument, and Congaree Swamp National Monument (USGS [2], 2001). Of these parks, all vegetation maps except Congaree Swamp and Rock Creek Parks are now complete. Parks of different sizes with a variety of vegetation were chosen to test sampling and mapping procedures that would meet accuracy requirements while conserving time.

Table 3. Park sizes indicating sampling approach used.

Park Size Class	Approximate Size	Sampling Approach
Small Park	< 1 km^2	Every polygon
Medium Park	1 100 km^2	Representative polygons across entire park
Large Park	100 2,500 km^2	Gradsect
Very Large Park	> 2,500 km^2	Multiple gradsects per ecoregion

In order to follow the current standards in place and further develop field procedures, similar procedures were used at these parks. Different scales of photography were used, the smallest scale being 1:24,000 (in compliance with Program standards). The majority of parks acquired higher resolution CIR photography. CIR imagery decreases haze and makes vegetation easier to see because of its high IR wave reflectance (Douglass, 1973). Past data on each park was collected on the vegetation and disturbance history, and a site visit was conducted to record present vegetation. From this information and with an initial site visit to the park, a vegetation classification key was developed. Most classes could be identified in the NVCS, with few exceptions of invasives, for which the researchers created placeholder categories for mapping purposes. For non-vegetative cover, The Anderson Land-use and Land-cover Classification System for use with remote sensor data Level II classification was used.

The normal process in vegetation mapping is to require the photographer to conduct a field reconnaissance once the photography is acquired. The interpreter then maps the vegetation units through photo interpretation, after which field verification is conducted. Field reconnaissance serves to familiarize the interpreter with the photo signatures of the plant species in the aerial photography, and allows the interpreter to become familiar with the vegetation types that occur in the study area (Aerial Information Systems, 1998). Information collected during the reconnaissance aides with vegetation delineation on the photographs. Mylar overlays affixed over each photo were used to draw vegetation polygons over the images while preserving them.

Once homogenous groups of vegetation were marked on the aerial photo mylars, photo interpretation field verification was performed. This process was a verification of the preliminary mapping, insuring the initial photo signatures were accurate. A team also worked with a TNC ecologist doing on-site field investigations, recording species present at each site. A final photo interpretation was completed after this verification, and then accuracy assessment was carried out as set forth by the USGS-NPS standards (Aerial Information Systems, 1998).

Vegetation maps for the USGS-NPS Vegetation Mapping Program are required to be in a transferable digital form, so the mylar sheets were next scanned into a digital database. A spreadsheet was populated with sequence number assignment for each polygon and other polygon attribute codes assigned to indicate community code, height code, density code, and land use code attributes. ArcInfo was used on these initial vegetation maps to scan the data, assign polygon identifiers to the data, create topology, and then join the attributes from the spreadsheet to the spatial data. Codes attached to each polygon were checked for validity in ArcInfo. Then georeferencing and digital registration of data was carried out in ArcEdit, using a master tic file that linked features from the each mylar sheet to the orthophoto.

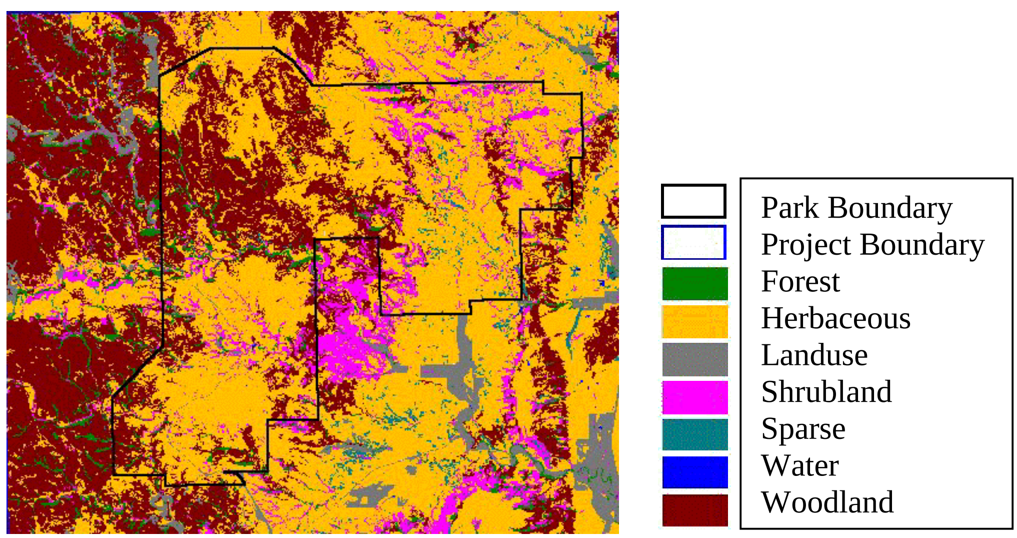

Figure 3. Wind Cave National Park Vegetation Map.

The method described above was used to create vegetation maps for Agate Fossil Beds, Fort Laramie, Scotts Bluff, Tuzigoot, Congaree Swamp, Rock Creek, and Wind Cave National Park (Figure 3). The Wind Cave National Park Vegetation map above is an NVCS class map produced in 1999 according to USGS-NPS guidelines (Cogan et al., 1999). A similar procedure that substituted "heads-up" on-screen digitizing in ArcInfo for the scanned mylar sheets was used at Jewel Cave National Monument, Devils Tower National Monument, and Mount Rushmore National Historic Site to create vegetation maps. In all, eight NPS units are classified as 'completed', indicating that the required data is in place, program procedures have been followed, and final reports finished. Most parks met their required accuracies positionally and thematically. The units that did not generally had specific classes that fell within the 90% confidence intervals in omission or commission errors, such as Devils Tower (Salas and Pucherelli, 1998). These parks' vegetation maps therefore met the "usability" standard of the NPS program. There are twenty-two 'parks are in progress', and 30 are slated as '2001 starts' (USGS [2], 2001). Congaree Swamp and Rock Creek Park are two of the seven parks with data available currently under the 'parks in progress' banner, but the reports for these projects are not complete. No data is available yet from the USGS-NPS Program regarding the '2001 starts' including Appomattox Court House National Historical Park.

2.2.2 Past Users of the NVCS with Remote Sensing

Due to the recent national vegetation classification development, few vegetation maps have been developed with this classification system. Two vegetation mapping projects using the USGS-NPS Program standards were successfully accomplished using softcopy photogrammetry by Bill Millinor (Millinor, 2000) and by Frank Koch (Koch, 2001). Millinor used scanned large-scale aerial photos with manual stereo viewing to produce a formation map with high thematic accuracy for Petersburg National Battlefield (PNB). Manual stereo viewing was used for vegetation class decisions. The ArcMap program from Environmental Systems Research

Institute, Inc. (ESRI) was then used for “heads-up” on-screen vegetation polygon digitizing. His success in producing an orthorectified photo mosaic as a result of block triangulation and image orthorectification marked the first vegetation mapping project with these elements (Millinor, 2000).

Koch developed Millinor’s mapping concept further, producing a highly accurate NPS vegetation formation level map, both thematically and positionally, using similar mapping techniques (Koch, 2001). Koch’s formation map covered Valley Forge National Historical Park. Both Koch and Millinor’s formation maps were assessed using the USGS-NPS accuracy assessment procedures described later in this paper. Koch then prepared Valley Forge’s aerial photography in Erdas Orthobase, allowing him to view the images in stereo on-screen with Erdas Stereo Analyst. Once a triangulation solution was calculated for the entire block. This process required the camera calibration report from the photo mission, interior photo orientations, a horizontal coordinate reference (such as a DOQQ), and a vertical reference for each point (such as a DEM). This procedure allowed a fully automated draft alliance map to be produced. Accuracy of the alliance map has not yet been assessed.

Few current examples of vegetation classification using the NVCS and satellite imagery are available. One example is a study by LaPlaca (2000), which developed decision rules for classifying vegetation. Field plots were marked, and LaPlaca formulated classification rules for the plots’ spectral values to determine the alliance level. Landsat imagery was manipulated in Erdas Imagine, a software package for processing satellite data sets. LaPlaca found insufficient ground data to determine accuracy of her map. She concluded that decision rules to determine the alliance level from this imagery was not possible. She questioned the use of a small number of sampling units with supplemental information from literature, Landsat TM data, and digital elevation models (DEMs) as realistic (LaPlaca, 2000).

An iterative, "map-guided" classification approach using the NVCS was developed to compile a spatially and thematically consistent, seamless land-cover map of the entire Intermountain Semi-Desert ecoregion by Stoms and his fellow scientists (Stoms et al., 1998). A multi-temporal dataset derived from Advances Very High Resolution Radiometer (AVHRR) data was classified using sub-regional maps as training data. These smaller maps usually had different classification systems designating land-cover, and these classifications were cross-walked for each map to NVCS alliances using a decision tree approach. In ArcInfo GRID, an iterative, supervised classification was used in image processing after an initial unsupervised clustering to obtain classes. Classes were then assigned to a cross-walked alliance with the highest association level to that spectral class. The resulting regional map attempted to meet the guidelines of the NVCS for classification at the alliance level, but no accepted methodology exists for assessing accuracy for small-scale mapping. Researchers developed their own accuracy assessment because no procedure exists for validating vegetation plots classified using satellite data. One square kilometer field plots already surveyed by the USGS Eros Data Center to validate the 1990 land cover regions database were used by Stoms to assess his vegetation alliances. Comparing the 78 plots representing the region to the original maps, 88 percent of assigned classes on the AVHRR map were labeled with correct or reasonable types. Spatial accuracy was improved in the final map by a factor of two according to this method. This mapping approach produced a regional alliance map from existing source maps that provided an accurate spatial map according to these methods while maintaining the thematic accuracy of smaller maps (Stoms et al., 1998).

2.2.3 Digital Mapping Methods

Satellite imagery, as used by LaPlaca and Stoms, provides an immediate digital data source due to the electronic collection method used to capture data. LaPlaca employed two Landsat TM scenes over the Great Smoky Mountains for her research. Erdas Imagine digital image processing software was used to cluster spectral values in the scenes initially. An unclassified classification was then run to sort values into classes to identify alliances. Stoms used ArcInfo GRID to run an unsupervised clustering on random pixels, and then executed a standard maximum-likelihood classifier to assign unsampled pixels to these clusters. The information classes in the map were compared with the spectral clusters, and the cluster with the highest level of association was assigned to its corresponding information class (Stoms et al., 1998).

Welch and fellow researchers attempted to create a proposed land-cover map and digital database for the Sapelo Island National Estuarine Research Reserve in 1992 (Welch *et al.*, 1992). A classification was constructed for the study area using field data and aerial photography. Due to the large natural area with few landmarks, obtaining sufficient ground control for mapping was difficult. An Alabama contractor, using a network of global positioning system (GPS) receivers, configured 16 ground control points (GCPs) for the island. An aerotriangulation was then done by a Florida company using these GCPs, producing 83 additional points. A digital GIS database was then created with this information. The aerial photography was scanned and successfully mosaicked together using ArcInfo software. Planimetric features were extracted and classification of the island land-use and land-cover types was accomplished using the GCPs in the database. These elements along with existing DEMs, USGS topographic maps, and land use/land cover maps were incorporated into the database to aid reserve managers in planning for the island's future. This digital database provided transferable digital data while overcoming obstacles with softcopy photogrammetry through acquiring the ground control network of points.

Catts et al. produced GIS data layers using an on-screen stereo viewing program, DVP, and a GIS (ESRI ArcView) (Catts et al., 1998). DVP was the first viable off-the-shelf softcopy photogrammetry package, providing on-screen stereo viewing and delineation between two monitors. An individual classification scheme was developed for this study with 12 broad classes that would meet the needs of the Environmental Protection Agency (EPA), United States Forest Service (USFS), and Natural Resources Conservation Science (NRCS). Multi-date photography of the large sample plot was scanned at 700 dots per inch (dpi) to produce the digital imagery for this study. This stereo system provided chronological imagery analysis and capture of land features that had changed. Land feature changes were delineated onscreen, but the DVP files were produced in a drafting software format, which required conversion for use with the ArcView GIS information. DVP used a block triangulation method to determine image coordinates by applying a transformation to the pixel coordinates. For absolute orientation, these researchers matched three GPS-collected ground points with the photos when setting up the stereo model to increase accuracy. Once the stereo models were in place, the most significant problem researchers had between the two programs was data not alligning automatically. The two-dimensional GIS layers exported from ArcView required manual adjustment so that the layer coordinates matched those in the DVP display. Before this adjustment, data from ArcView appeared to "float" just above the corresponding DVP layers. Softcopy photogrammetry was able to provide estimates of land-cover change relevant to forest health and sustainability in a GIS (Catts *et al.*, 1998). Time was saved with the softcopy approach because of the ability to iteratively edit classifications, and data manipulation in GIS was available with immediate editing of spatial information in DVP. A digital, editable product that is transferable to other users in electronic form resulted from Catts study.

Millinor (2000) and Koch (2001) created digital imagery using a desktop scanner to scan and import each air photo into Erdas Imagine image format. Both researchers used manual stereo viewing and on-screen delineation in ArcMap to create a vegetation data layer. An orthophoto mosaic of the imagery was produced for both projects as well.

The goal of this study is to enhance the procedures begun by Koch (2001) and Millinor (2000) to allow a fully automated classification procedure.

2. Objectives

This study had two main objectives:

- Develop a digital protocol for mapping vegetation to the NVCS formation level while meeting the USGS-NPS Vegetation Mapping Program standards;

- Produce a formation-level vegetation map that is at least 80 percent thematically correct for Appomattox Court House National Historical Park.

4. Materials and Methods

4.1 Obtaining Digital Data

Current park boundary information was available through CEO from Appomattox data previously converted from Atlas GIS data to ArcView shape files for the NPS. Andrew Martin, a graduate student, converted the digital layers for Appomattox Court House, including: boundary, buildings, trails, utility lines, soils, roads, and USGS DEM and digital line graph (DLG) data.

4.1.1 Aerial Photography

Photography used in this mission was contracted by the Natural Resources Specialist at Appomattox Court House to American Photographics, Incorporated, a company that has conducted other photo missions over national parks including Valley Forge. The mission was flown December 18, 2000, producing 50 CIR photographs at a scale of 1:6,000 along five flight lines. The flight lines ran east to west with three lines flown west and two east. CEO received these photos January 19, 2001.

The photography was scanned with an EPSON Expression 836XL desktop scanner using Adobe Photoshop 5.0 software. Adobe functions under the Import option were set to normal scan mode, 36-bit color, and no filters at 600 dots per inch (DPI) scanning resolution. These settings were consistent with Koch’s (2001) photography scanning selections for his draft alliance map. The scanned images were saved as Tagged-Image File Format (TIFF) files. These TIFF images (*.tif) were then converted to Erdas Imagine image files (*.img) using Imagine software.

4.1.2 Digital Orthorectified Quarter-quadrangles

Four 1996 USGS color infrared (CIR) Digital Orthophoto Quarter Quadrangles (DOQQs) (Vera Southwest, Vera Southeast, Appomattox Northwest, Appomattox Northeast) were provided by park staff. An Internet data check of USGS holdings was conducted, and the 1:40,000 National Aerial Photography Program (NAPP) CIR imagery used to generate these DOQQs is the most current photography available. The park boundary fell on the inner edges of the four files, requiring the DOQQs to be mosaicked for complete coverage of the park's acreage. These DOQQs served as the X- and Y-coordinate reference for digital orthorectification of the scanned air photo images. Original files were in binary sequential (*.bsq) format and were imported into Imagine and converted to Imagine image files. The 'Data Preparation' procedure in Imagine was used to identify the best vegetation coverage on each image. Areas-of-interest (AOIs) were then delineated on each DOQQ. The images with their respective AOIs were then added to the image list in the 'Mosaic' procedure which mosaicked the four images into one. The color balance between the four files was poor, but little can be done to fix these differences without degrading the features of the images so their original band values were not changed for analysis purposes. Using the 'Projection' option under 'Data Preparation', the DOQQ mosaic was assigned projection information to match existing park data layers. Projection settings for this project are:

Projection: UTM
Units: Meters
Z Units: Meters
Datum: NAD 83
Zone: 17 North
Spheroid: GRS 80

4.1.3 Digital Elevation Models

Park staff provided USGS DEMs from 1996 as well, but an alternative DEM source was obtained in the newly constructed National Seamless Elevation (NSE) dataset, which has vertical errors estimated to be three to four meters (Osborne, 2001). The USGS DEMs which were previously available have an average error of seven meters in elevation (Osborne, 2001). The DEM values provide the vertical mean height above sea level data for the orthorectification process. This NSE DEM dataset was acquired from the NSE site (http://edcnts14.cr.usgs.gov:81/website/seamless.htm). Approximately half of Appomattox County was selected to insure the entire mapping area was covered, and the resulting file was received through a file transfer protocol (ftp) server two days later.

The DEM arrived as a zipped file in DEM grid format, which was extracted with WinZip software, then prepared and reprojected with ArcInfo 7.2.1 (see Appendix A for ArcInfo NSE DEM processing commands). Standard USGS DEM resolution is 30-meter pixels, a course resolution for this large-scale mapping project. To increase elevation data, the DEM was resampled to 10-meter pixels in ArcInfo (see Appendix A for resampling commands). The DEM was then imported into Imagine format for use with Erdas Orthobase.

4.2 Orthorectification

Orthorectification is the digital process of removing the radial tilt and relief distortion inherent in aerial photographs (Bolstad, 1992).

Orthobase image orthorectification is conducted in a “block” file. This file, or “photo block”, requires the frame camera model used to collect the images in the block, the images themselves, the interior and exterior orientations of each image, tie points that link each image together, and GCPs that link the images to the DOQQ and DEM. Orthobase used these elements together for triangulation.

To build a photo block, the fifty aerial images to be rectified first had to be added to the block file. Then the frame camera model was defined (see Appendix I for camera calibration report). This information was provided in the mission report from Aerial Photographics. Camera type, calibrated principal point, focal length, fiducial offsets, and radial lens distortion coefficients were entered into Orthobase. The camera model was then saved in a file for future use.

With the images and camera information in place, the interior orientation of each image had to be established. Each image was opened in the Interior tab window in the block file. A cross-hair cursor was used to place a point at the center of each fiducial, a fiducial being one of eight edge marks printed on the center edge or corner of an aerial photo to aide in photo orientation. Marking these fiducials indicated to Orthobase where given interior locations fell in each image. Calibration of these points must be done manually (moving the applied point with the mouse) until the root mean squared error (RMSE) for each image's interior orientation solution is less than 0.33 pixels (ERDAS, Inc., 1999). One of four possible conventions, each represented by a corresponding key, for fiducial orientation had to be selected for each image for interior orientation as well. The convention options indicate the relationship between the photo-coordinate system and the image's position, and are assigned by the location of the data strip on the image (ERDAS, Inc., 1999). Images in the first, third and fifth flight lines did not require rotation, but the images for the second and fourth lines required a 180-degree rotation for proper interior orientation.

Once the interior orientations were entered for each image, the exterior orientation parameters had to be set. Orthobase does not require this value for calculating an initial triangulation, so a value of 'initial' was entered when the block was set up. Exterior orientations are estimated when the software calculates a triangulation solution, and the user must accept or reject these values based on the amount of error they allow in the block for that solution.

With the photo block completely set up, manual tie point collection was the next step toward orthorectification. A tie point is not a geographically referenced point, but simply a point co-located on two photos that cover a similar geographic area. To create these points, the Point Measurement Window (Figure 4) allows the user to add a new record for each tie point. Two images are displayed simultaneously in each side of this window. With two images that fall next to one another open in each side of the window, a cross-hair cursor allows the user to create a tie point on one image, such as the base of a traffic sign, by clicking on that point. The same landmark is then selected on the other image. A total of 171 tie points were manually placed between the fifty photos, which is more than the recommended average of two points between each photo on a flight line and two points tying together each flight line. Extra points were needed in this project as Orthobase generated some incorrect points between two end photos, a mistake identified during inspection of the first software-generated data.

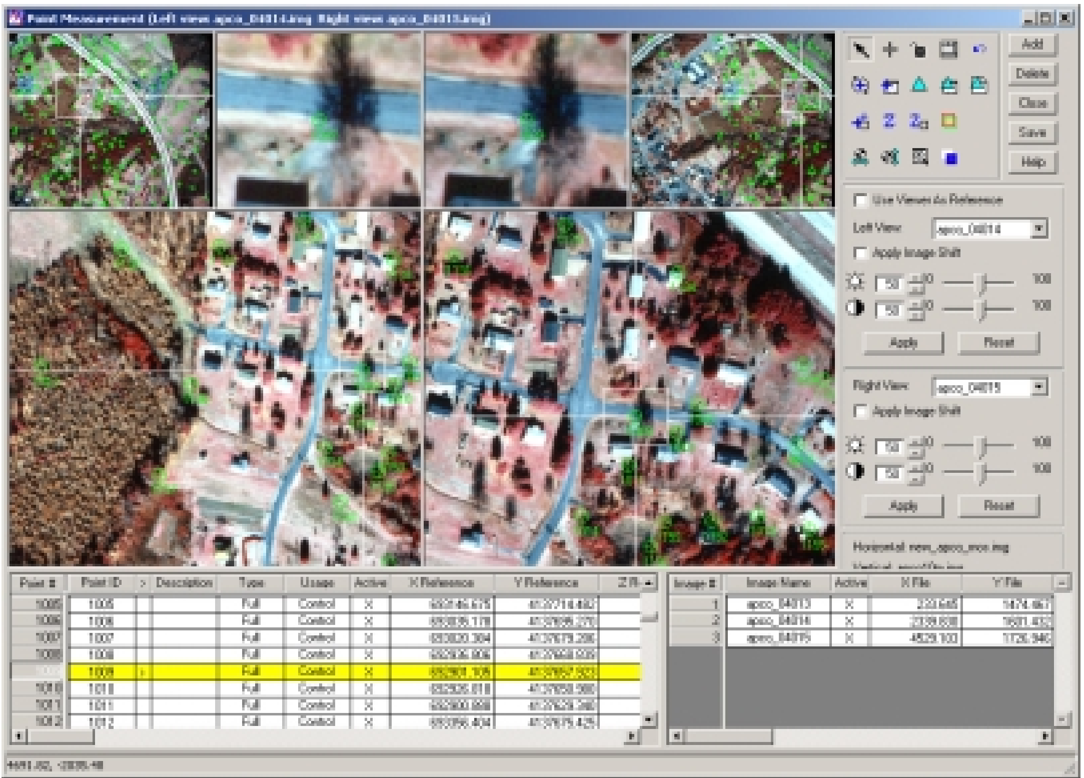

Figure 4. Point Measurement Tool window.

With the manual tie points in place, the ‘Automatic Tie Point Collection’ procedure was executed. This collection compares the similarity of the spectral values of the manually placed points, then attempts to generate additional points that model the spectral similarities provided by the manual points. Two hundred intended points were indicated for the procedure parameters, and the coefficient limit parameter was increased from the default value of 85 percent to 90 percent. This parameter sets the limit for the cross-correlation coefficient, and the higher limit made the automatic tie point assignment more discriminating in placing the new points (Erdas, Inc., 1999). Default values were accepted for the remaining parameters. Automatic tie point generation was successful, with none of the 4,821 checked points misplaced.

Aerial triangulation was the next step in orthorectifying the images collectively. This procedure in the Point Measurement Tool window required a horizontal reference and a vertical reference for GCP placement. The DOQQ image and DEM image served these purposes, respectively. Orthobase requires that GCPs be placed across the block at a minimum of one in every three images, and the edges of the photo block must have adequate ground control coverage (Erdas, Inc., 1999). More points than were required by Orthobase were placed in the block, a total 230 GCPs. Several solutions were reached with less GCPs, but they generated high overall RMSE. Orthobase indicated problems with several images that fell on the end of flight lines, these images having very distorted Kappa values in the triangulation reports. The Kappa value is one of the exterior orientation parameters that indicate the estimated photo position in the photo block. Adding more GCPs to these end images was the only suggestion that the Erdas Orthobase Tour Guide and other research provided to help with this problem. Adding more GCPs did not produce a solution.

The end images were subtracted after the interpreter insured that when they were taken out no park boundary coverage was compromised. The triangulation was successfully run with the ‘Timesaving Blunder Checking’ and ‘No Additional Parameters’ options selected under the ‘Triangulation Options’ procedure, producing an acceptable solution. The overall RMSE for this initial triangulation was 1.109 meters, error in the X-coordinate being 0.702 meters, 0.734 meters in the Y-coordinate direction, and 1.6 meters in the Z-coordinate. The estimations made for the exterior orientations of each image were then updated and the coordinate estimations for the tie points accepted, creating an additional 4,821 GCPs.

Triangulation was then run again on the block with the parameters in Table 3, producing 0.906 meters error in the X-coordinate direction, 1.296 meters error in the Y-coordinate direction, and 3.506 meters error vertically. See Appendix K for the triangulation report with the X, Y, and Z components of the RMSE and the estimated exterior orientation parameters and their accuracies.

Table 4. Aerial triangulation parameters.

Aerial Triangulation Parameters	
Maximum iterations:	7
Compute Accuracy for Unknowns	no
Image Coordinate Units for Report:	pixels
Convergence Value (meters):	0.001
Image Point Standard Deviations (pixels):	x, y = 0.33
Point type:	Fixed values
Interior, type:	Fixed for all images
Exterior, type:	No weight
Additional Parameter Model:	No additional parameters
Insert Additional Parameters as Weighted Variables:	no
Blunder Checking Model:	No automatic blunder checking
Use Image Observations of Check Points:	yes
Consider Earth Curvature in Calculation:	no

The Imagine files generated from the scanned aerial photography, DOQQs, and DEM are the basis for orthorectification in the Erdas Orthobase methodology. Once the triangulation solution was in place, the images all had an orthorectification solution. The interior and exterior parameters were defined for each image, GCPs were distributed throughout the block, and the images were ready for stereo viewing in Stereo Analyst. An orthophoto was generated using bilinear interpolation for each image in Orthobase.

4.3 Photo Mosaic Construction

Constructing the photo mosaic began with selecting areas-of-interest (AOIs) for each orthophoto. Each image was opened in an Imagine viewer, and then the AOIs were chosen using the polygon tool in the AOI Tools. AOIs were chosen based on the coverage each orthophoto represented of the park, and the color quality of the orthophoto. Photos with dark coloring or shadow did not have very large selected areas for use if another photo covered the same acreage and had more a bright, balanced quality.

With the AOIs in place, the images were then added to the ‘Mosaic Tool’ procedure in Imagine. The AOIs were assigned to their designated images in the image list. In the menu under the ‘Set Overlap Function’ procedure, the ‘No Cutline Exists’ option was chosen as the intersection type, and the ‘Feather’ option for the select function was chosen. ‘Union of All Outputs’ was the output option specified. Portions of all images in the triangulated photo block were included in the photo mosaic. All other values were left as the default settings. Figure five illustrates the mosaic definition for the photo mosaic with each image AOI.

Once the mosaic was constructed, Multi-Resolution Seamless Image Database (MrSID) software was used to compress the photo mosaic file from 1.08 gigabytes to 39.00 megabytes. This smaller file is faster and easier to manipulate in ArcView, the GIS software used at Appomattox Court House.

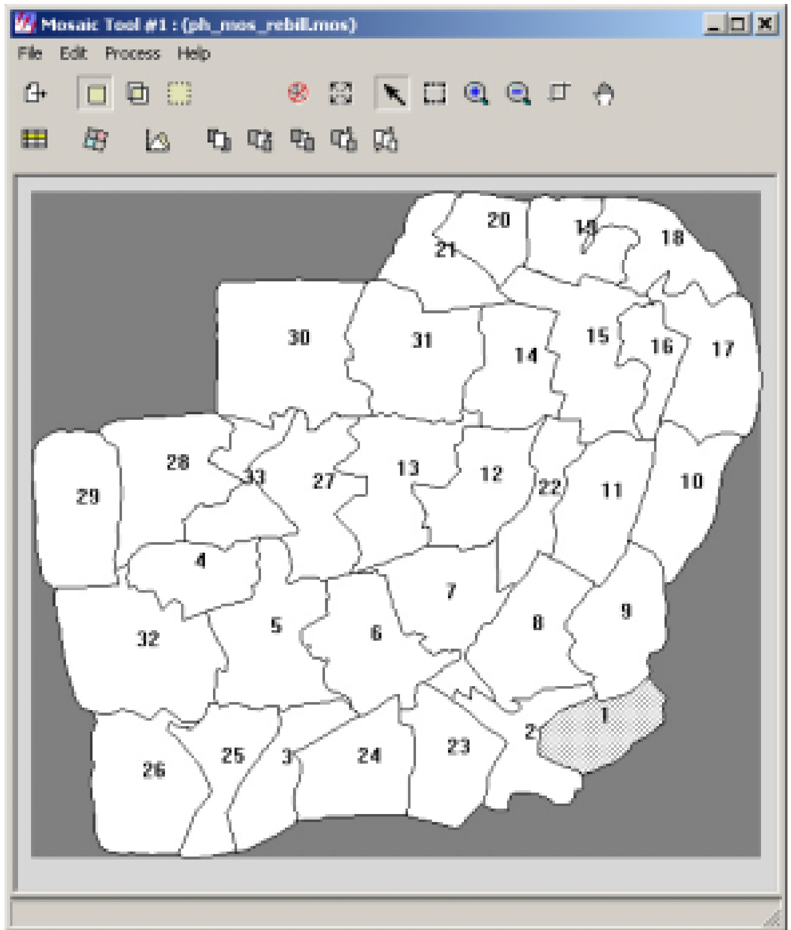

Figure 5. Photo mosaic definition in Erdas Imagine Mosaic Tool.

4.4 Photography Classification with Stereo Modeling

Appomattox Court House park photography is larger scale than most previous USGS-NPS projects at a 1:6,000 scale. Air photos were acquired for this study over the park during December 2000 in leaf-off conditions, recorded on CIR film. Vegetation delineation took place on-screen using the digitized imagery, eliminating the data conversion steps described in prior NPS vegetation maps. No initial field visit was made to Appomattox Court House, though the interpreter used CIR digital orthorectified quarter quadrangles (DOQQs) to initially classify the area and to familiarize her with the land cover types and uses present. Before beginning vegetation classification, an initial list of possible formations and alliances present in the park area was compiled by studying regional vegetation and reviewed by Gary Fleming of Virginia NHP. This edited list served as the list of formations and possible alliances applied to stands during the preliminary vegetation classification process. See Appendix L for the initial formation and alliance list.

Once the photo block had a triangulation solution, the block was now viewable in Stereo Analyst. The block was opened, and a feature project was created that included the block, the park boundary, and a new line feature for vegetation delineation. Creating a feature project facilitated efficient work time in Stereo Analyst. The layers required for mapping were all opened once the feature project was in place, instead of opening each individual data piece and adding it to the view.

Figure 6. Stereo Analyst system set up with user wearing goggles.

The Erdas Stereo Analyst workstation requires a color monitor with a high refresh rate and an emitter box that is affixed to top of the monitor. The mapper must wear a pair of battery-powered goggles that flash 120 fields per second. These flashing goggles are struck by the emitter waves and, with the high-refresh rate of the Mitsubishi 29-inch monitor, allow the mapper to view a photo pair on-screen in stereo. The goggles used for this project were Crystal Eyes™ from Stereographics.

A line feature was used to delineate the park vegetation because line shape files are easier to manipulate and edit than polygon features. Stereo Analyst opens one photo pair at a time, highlighting the overlapping area within a blue, line-bounded box. The area within the box is in stereo. The mapper must be careful to survey the effective area, not mapping too close to the edge of the stereo viewing box because some features may be distorted farther from the center of the photo. With the vegetation line shape file selected, each area greater than one half acre with homogenous features was delineated. A yellow crosshair cursor manipulated by the mouse was used to create the lines for marking vegetation polygons.

When all stereo pairs had been examined and delineated, the vegetation line shape file was exported from the feature project. The shape file was then converted to an ArcInfo coverage, cleaned, and built as a polygon coverage (see Appendix B for line shape file to polygon shape file processing commands). This coverage was then opened in ArcView 3.2 and converted to a shape file. The shape file consisted of 399 polygons, 309 of those being vegetation. The other 90 polygons consist of roads, barren land, and other human-impacted areas.

For polygon classification, the new vegetation polygon shape file was opened in ArcView, and the corresponding photo pair was opened in the Stereo Analyst feature project. Each polygon was then labeled with the NVCS formation identified by the mapper from the photography. A "possible alliance" was also assigned to each polygon based on VPI's 1986

Forest Management Plan and on the detail the mapper could detect from the stereo pair. The formation classification was the level assessed for accuracy, so the alliance assignment was simply an attempt to aid in further field research for the Virginia NHP. No classes indicating human development are defined in the NVCS, so The Anderson Land-use and Land-cover Classification System for use with remote sensor data Levels I and II were used for human-impacted areas. Using the Anderson classification is consistent with past USGS-NPS Vegetation Mapping Program projects that used this scheme for developed areas (USGS[2], 2001). See Appendix G for the Anderson Levels I and II identified at ACHNHP.

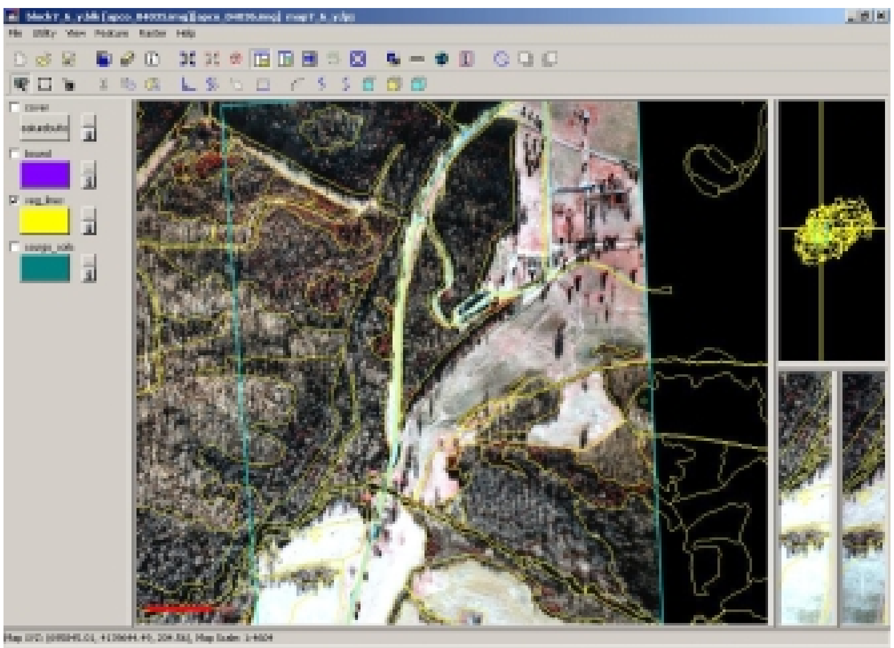

Figure 7. The Stereo Analyst digitizing interface.

4.5 Accuracy Assessment

To begin thematic accuracy assessment of the vegetation map, the mapping program Sampling Stratification Guidelines (see Appendix G for USGS-NPS Thematic accuracy assessment sampling scheme) required that a specified number of plots per class be visited. Earlier research at CEO indicated that the closer a sample point was to a boundary, the more likely it was to be misclassified (Styron, 1991). With this in mind, sample points were generated using an ArcView script constructed by Frank Koch of CEO. The script uses the USGS-NPS standards for the number of plots required per NVCS class and generates a summary table for the classes (refer to Appendix H for the sampling script).

In ArcView 3.2, the park formation vegetation map shape file was opened. Koch's summary script was chosen, and a classification summary table was generated that summed the number of polygons that were classified by each formation and the total hectares and acres that each formation covered in the vegetation map (Table five).

Table 5. Number of polygons in each formation, hectares, and acres for the map classes.

NVCS Formation	Count	Hectares	Acres
I.A.8.C.x Planted/Cultivated Temperate/Subpolar Needle-leaved Forest	22	53.7	132.7
I.A.8.N.b Rounded-crown Temperate/Subpolar Needle-leaved Forest	84	102.8	254.0
I.A.8.N.c Conical-crown Temperate/Subpolar Needle-leaved Forest	18	8.2	20.2
I.B.2.N.a Lowland/Submontane Cold-deciduous Forest	89	344.5	851.2
I.B.2.N.d Temporarily Flooded Cold-deciduous Forest	28	82.4	203.6
I.B.2.N.e Seasonally Flooded Cold-deciduous Forest	1	3.0	7.5
I.C.3.N.a Mixed Needle-leaved Evergreen Cold-deciduous Forest	3	1.2	3.0
II.3.C.N.a Mixed Needle-leaved Evergreen Cold-deciduous Woodland	1	1.0	2.5
II.A.4.N.a Rounded-crown Temperate/Subpolar Needle-leaved Woodland	1	4.0	9.8
II.B.2.N.a Cold-deciduous Woodland	1	2.2	5.4
II.C.3.N.a Mixed Needle-leaved Evergreen Cold-deciduous Woodland	5	8.3	20.6
III.A Evergreen Shrubland	3	6.9	17.1
III.A.2.N.a Temperate Broad-leaved Evergreen Shrubland	3	1.3	3.1
V.A.5.C.x Planted/Cultivated Temperate/Subpolar Grassland	36	278.7	688.6
Agricultural Fields	22	100.4	248.1
Cleared Forestry Area	7	33.9	83.7
Developed	26	38.3	94.6
Disturbed	6	2.0	5.0
Farm/unpaved roads	11	3.5	8.6
Roads	11	12.3	30.3
Water	16	7.6	18.9

The second step of the sampling script calculated the number of polygons that must be visited in each formation according to the USGS-NPS sampling scheme (see Appendix I for the thematic accuracy sampling scheme). Finally, the script randomly selected the polygons to be visited for each class. A point was dropped in the center of the polygon area to be assessed. Some polygons were not regularly shaped in the map, so each point was examined for placement. Some points required manual adjustment to fall more closely to the center of the polygon. The script then randomly numbered the points to discourage bias in the field plot positions by generating a separate list of numbers that corresponded to the number of polygons. Each polygon was assigned a random number from the number list, eliminating the number from

Figure 8. Thematic accuracy points assigned by script on the orthophoto mosaic.

the number list and assuring polygon numbers were not duplicated for identification purposes. When all polygons had a number designation, the number list was empty. This random identification generation greatly decreased the time involved in the planning process of the accuracy assessment. Coordinates were generated for each thematic accuracy plot to be visited – 203 plots for this study. The plots were generated as points in an ArcView point shape file, and the summary table was inspected to insure accurate coverage of all classes. These points were opened in ArcView with the photo mosaic as a backdrop and labeled by number (Figure 8). This layout was then plotted for field navigation. The plot coordinates were loaded as waypoints in a Trimble ProXRS GPS unit as well to aid in finding these locations in the park.

In the field, a USGS-NPS Vegetation Mapping Program Accuracy Assessment Form was filled out for each of the 196 plots visited (see Appendix M for an example of the USGS-NPS Vegetation Mapping Program Accuracy Assessment Form). Six plots were not visited due to being on private property outside of the park boundary and difficult to reach. One other point was not visited due to time constraints. The elevation for each point was taken from the GPS unit and recorded on the assessment form along with the aspect of the plot, and the major species present by strata. An alliance was assigned to the plot based on the ecological factors present.

Post fieldwork, the plots were inserted into an error matrix to calculate the thematic accuracy results (Table seven). A summary table of plots was also compiled during this process.

For positional accuracy assessment, 46 landmarks were chosen as points and plotted on the orthophoto mosaic for field navigation purposes. According to Millinor (2000) and Koch's (2001) accuracy assessment procedures, 40 points were collected to conduct the assessment. Several extra points were collected to insure 40 good points. The points were field checked using the Trimble GPS unit with real-time correction. There was not a correction signal in immediate proximity to the Appomattox area (Richmond was the closest beacon). Several points had variable amounts of corrected positions as the signal's strength varied, and the total number of real-time corrected points after data download was 37. Differential correction was performed using Trimble Pathfinder version 2.70 software for post-processing the data, and two more points were corrected for a total of 39 positional accuracy points. These points were then compared to the same points taken from the orthophoto mosaic to ascertain the mosaic's positional accuracy (Figure 9).

5. Results

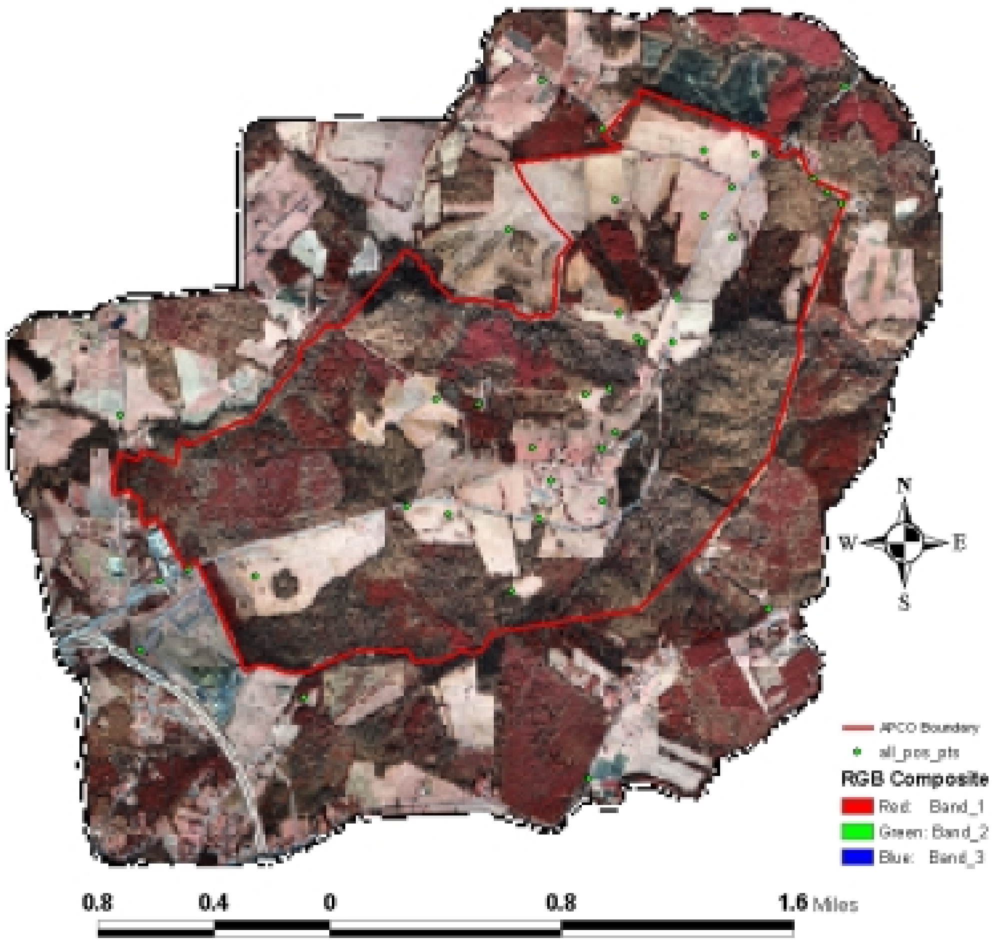

Figure 9. Positional accuracy point distribution on the MrSID photo mosaic.

5.1 Orthophoto mosaic

According to the American Society of Photogrammetry and Remote Sensing (ASPRS), positional accuracy of a map should be assessed by calculating the RMSE, in terms of the area's planimetric survey coordinates (X, Y), for field checked points as determined at full scale of the map, or collected on the ground (ASPRS, 1990). Over 40 points were collected inside and at locations around the park with GPS for positional accuracy assessment. Thirty-nine of these points were corrected with either real-time or differential correction, and used to calculate positional accuracy. Error in these positions are accounted for by the equation (Merchant, 1985):

$$RMSE_x = \left[\frac{1}{N} \sum_{i=1}^{n} (\delta X_i - \delta X_c)^2\right]^{1/2}$$

where $RMSE_x$ is the standard error in the x-coordinate direction, N is the sample size, δX_i is the actual (measured) coordinate location, and δX_c is the true coordinate location as determined in the source of higher accuracy (Bailey *et al*., 1994).

Determination of positional accuracy conformance to NMAS is done with a hypothesis test. The null hypothesis is that the required standard error and the estimated standard error are the same. This hypothesis is represented by a variable with a chi-squared value and *n*-1 degrees of freedom:

$$X^2 = \left[\frac{(n-1)}{\sigma_x} RMSE_x\right] \qquad \text{(Bailey et al., 1994)}$$

where *n* is the sample size, σ_x is the required accuracy standard and $RMSE_x$ is the estimated standard error. The null hypothesis is accepted if the calculated chi-squared value is less than the expected chi-square value at a 95 percent confidence level with *n*-1 degrees of freedom. According to Bailey et al., the expected chi-square value is 53.38. Table six contains the calculated chi-squared values. The mosaic fails to reject the null hypothesis at Class 1 level for the X-coordinate direction and at Class 2 for the Y-coordinate direction.

Table 6. Positional accuracy chi-squared statistics for the photo mosaic.

	NMAS Map Class:	
	Class 1 (S. E. = 1.5m)	Class 2 (S.E. = 3.0m)
X-coordinate direction	15.27595	7.637975
Y-coordinate direction	61.19516	30.59758

Calculations of the 39 X- and Y-coordinate RMSE values are detailed in Appendix L. The mean RMSE accuracy was determined for the points. According to the planimetric coordinate accuracy requirement, the photo mosaic meets Class 1 accuracy standards in the X-coordinate having an RMSE of 0.603 meters, falling below the 1.5 meter limiting RMSE specified by the American Society for Photogrammetry and Remote Sensing (ASPRS). The Y-coordinate falls into Class 2 horizontal accuracy standards, the Y RMSE being 2.415 meters exceeding the 1.500-meter RMSE limit. The photo mosaic is Class 1 accurate in the X-coordinate direction and Class 2 accurate in the Y-coordinate direction.

Mean Euclidean distance of the positional accuracy points is another method to compare the accuracy of the photo mosaic. The total number of survey points, the difference between the map and collected X-coordinates for a point, and the difference between the map and the collected Y-coordinates for the survey point were used to obtain this value. The mean Euclidean distance is 1.475 meters for the photo mosaic, with difference values ranging from 0.074 to 4.460 meters.

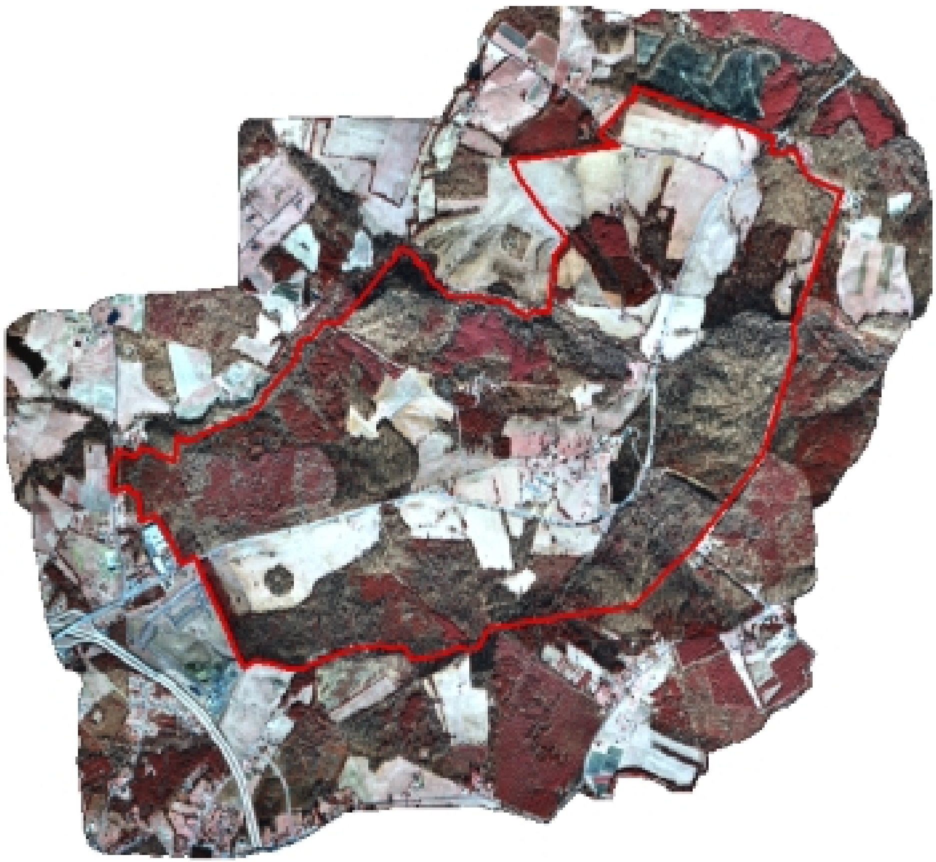

Figure 10. Final photo mosaic with the park boundary.

5.2 Formation vegetation map

From the error matrix (Table eight), the thematic statistics were calculated. Class III.A Evergreen Shrubland was a class that served as a placeholder created by the interpreter. All other classes are NVCS formation classes. From the photography, the interpreter decided that the evergreen growth present was not tall enough to be woodland and not dense enough to be classified as forest. These areas were hypothesized to be areas of *Pinus virginiana* that were in succession back to forest from some disturbance. No given NVCS class formation description qualified for the physical characteristics of the vegetation. This placeholder was instated because the interpreter acknowledged that the area would probably grow into woodland or forest by the time of ground assessment, which these three respective polygons had done. Several forests were misclassified as temporarily flooded forest formations instead of simply cold-deciduous forests, but hydrologic regime is not readily apparent even with Stereo Analyst capabilities. These areas were classified based on the perceived slope and aspect of the land by the interpreter.

The polygons that were checked in the field and found misclassified were re-attributed as necessary. Other areas of the map were revised based on ground assessments and notes from fieldwork. If the 196 polygons that were surveyed are now correct, and if 77.55 percent of the remaining 202 polygons were correctly classified, the thematic accuracy of the revised formation map for Appomattox Court House is 88.70 percent.

Of the 196 plots visited, 152 were correctly classified on the vegetation map. Original overall map accuracy was 77.55 percent, approaching the USGS-NPS standard of 80 percent for overall thematic accuracy. Several statistical measures of thematic accuracy must be used to assess a vegetation map's true accuracy according to the USGS-NPS standards. These measures aid in compensating for errors introduced into the mapping process by data interpretation. A Student *t* hypothesis test was incorporated to indicate the significance of data results. The null hypothesis, therefore, is that the calculated accuracy of the map and the claimed map accuracy are the same. This test is accepted or rejected by a variable with a Student's *t* distribution and n-1 degrees of freedom, where n is the sample size, p is the claimed accuracy, and p_{hat} is the calculated accuracy (Bailey *et al*., 1994).

Table 7. Thematic accuracy assessment error matrix.

Reference Totals

Class	#	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Total Clas.	Total CE
I.A.8.C.x	1	14	1																								15	1
I.A.8.N.b	2	4	26		1			1	2				1														35	9
I.A.8.N.c	3		1	3																							4	1
I.B.2.N.a	4				26						1		1														28	2
I.B.2.N.d	5				4	13											1										18	5
I.B.2.N.e	6				1		0																				1	1
I.C.3.N.a	7	1	2		1			4																			8	4
II.A.4.N.a	8		2						0																		2	2
II.A.4.N.b.2	9									0																	-	-
II.B.2.N.a	10				1						1																2	1
II.B.2.N.b	11											0															0	0
II.C.3.N.a	12					1							0			1											2	2
III.A Evrgr Shrub	13		2										1	0													3	3
III.A.2.N.a	14											1			1	1											3	2
III.B.2.N.a	15															0											-	-
III.B.2.N.d	16																0										-	-
III.C.2.N.a	17																	5									5	0
V.A.5.C.x	18		1			1													16								18	2
Roads	19																			3							3	0
Farm/unpaved roads	20																				3						3	0
Urban or Built-up	21																					5					5	0
Cleared Forestry Area (Tr)	22															1			2				2				5	3
Agricultural Fields	23			1						1						1		1				1		21			26	5
Water	24																								5		5	0
Transitional Areas	25																		1							4	5	1
Total Ref.		19	35	4	34	15	-	5	2	1	2	1	3	-	1	4	1	6	19	3	3	6	2	21	5	4	**196**	
Total OE		5	9	1	8	2	-	1	2	1	1	1	3	-	0	4	1	1	3	0	0	1	0	0	0	0		

$$t = \frac{p_{hat} - p}{\sqrt{\frac{p(1-p)}{n}}}$$

The threshold value for a two-sided test at a 90 percent confidence level with 195 degrees of freedom is 1.653. The calculated t value is compared to this threshold value, and, if it less than the threshold, the map fits the NMAS for overall thematic accuracy. The calculated *t* value was 0.857, so the hypothesis was not rejected.

USGS-NPS Vegetation Mapping Program standards requires a 90 percent confidence interval be constructed around thematic accuracy with the following equation:

$$p_{hat} \pm \left\{ z_{\alpha} \sqrt{\frac{p_{hat}(1-p_{hat})}{n}} + \frac{1}{2n} \right\} \qquad \text{(Bailey et al., 1994)}$$

where n is the sample size, p_{hat} is the calculated accuracy, and z_{α} is the value from a z-distribution at significance level α, or 1.645. The confidence interval calculated for overall thematic accuracy is 72.40 percent to 82.70 percent.

The Kappa statistic was formulated by Cohen to indicate how much of an improvement a classification is over a completely random classification of the same area (Jensen, 1996). A certain percent of correctly classified polygons are correct classifications based simply on chance, even in the most confused classification (Goodchild, 1994). A statistical measure that aids in explaining this chance is this Kappa, or $k_{\text{hat},}$ statistic. The commission and omission errors are incorporated into the Kappa measure that are not incorporated into the standard overall accuracy calculation. The off-diagonal elements in the error matrix are figured into the probability that the classification is effective besides the total number of polygons correctly assigned. K_{hat} gives a statistical measure of how much better the given classification is than a completely random one using the formula:

$$K_{hat} = \frac{N\sum_{i=1}^{r} x_{ii} - \sum_{i-1}^{r}(x_{i+} \times x_{+i})}{N^2 - \sum_{i=1}^{r}(x_{i+} \times x_{+i})} \qquad \text{(Jensen, 1996)}$$

where *r* is the number of classes in the matrix, x_{ii} is the number of observations in the diagonal of the error matrix (the correctly classified polygons, row *i* and column *i*), x_{i+} and x_{+i} are the marginal totals for row *i* and column *i*, and *N* is the total number of survey points. Kappa value can range from zero, the least possible improvement, to one, the most possible improvement. Kappa for the formation vegetation map was 0.7506, indicating the classification was an improvement over a simple random classification.

Table 8. Producer's and user's accuracy.

	REFERENCE TOTALS	CLASSIFIED TOTALS	NUMBER CORRECT	USER'S ACCURACY (%)	PRODUCER'S ACCURACY (%)
I.A.8.C.x	19	15	14	73.68	93.33
I.A.8.N.b	35	35	26	74.29	74.29
I.A.8.N.c	4	4	3	75.00	75.00
I.B.2.N.a	34	28	26	76.47	92.86
I.B.2.N.d	15	18	13	86.67	72.22
I.B.2.N.e	-	1	0	-	0.00
I.C.3.N.a	5	8	4	80.00	50.00
II.A.4.N.a	2	2	0	0.00	0.00
II.A.4.N.b.2	1	-	0	0.00	-
II.B.2.N.a	2	2	1	50.00	50.00
II.B.2.N.b	1	0	0	0.00	-
II.C.3.N.a	3	2	0	0.00	0.00
III.A Evrgr Shrub	-	3	0	-	0.00
III.A.2.N.a	1	3	1	100.00	33.33
III.B.2.N.a	4	-	0	0.00	-
III.B.2.N.d	1	-	0	0.00	-
III.C.2.N.a	6	5	5	83.33	100.00
V.A.5.C.x	19	18	16	84.21	88.89
Roads (Urb.)	3	3	3	100.00	100.00
Farm/unpaved roads (Urb.)	3	3	3	100.00	100.00
Urban or Built-up	6	5	5	83.33	100.00
Cleared Forestry Area (Bar.)	2	5	2	100.00	40.00
Agricultural Fields	21	26	21	100.00	80.77
Water	5	5	5	100.00	100.00
Transitional Areas (Bar.)	4	5	4	100.00	80.00
Totals	196	196	152		

Overall Accuracy= 152/196=77.55%

Table eight indicates producer's and user's accuracy for each vegetation class. These accuracies are also referred to as commission and omission error, respectively. Producer's accuracy is the probability that an area in a certain class has been correctly identified as being in that class. User's accuracy is the probability that an area that has been identified as a certain class actually is that class. The values in table seven are the un-revised totals from ground assessment. The largest commission error was for Class I.A.8.N.b, or the Rounded-crown Temperate or Subpolar Needle-leaved Evergreen Forest Formation. The most considerable omission error came in Class III.B.2.N.a, or the Cold-deciduous Shrubland. These errors are reviewed in section 6.3 of Discussion under Misclassifications. The six classes with zero percent producer's accuracy is due to the interpreter's attempt to characterize vegetation very specifically physiognomically and ecologically. Upon field assessment, these classes were different ecologically than the interpreter had assessed. The class III.A Evergreen shrub is an example of this, as the interpreter could tell a height and canopy difference from woodland and forest, but deduced that these polygons were probably succeeding back to evergreen forest. These III.A Evergreen plots were identified as dense young *Pinus virginiana* forest in the field.

For a summary of all errors by sample plot, refer to Appendix J: Thematic accuracy data.

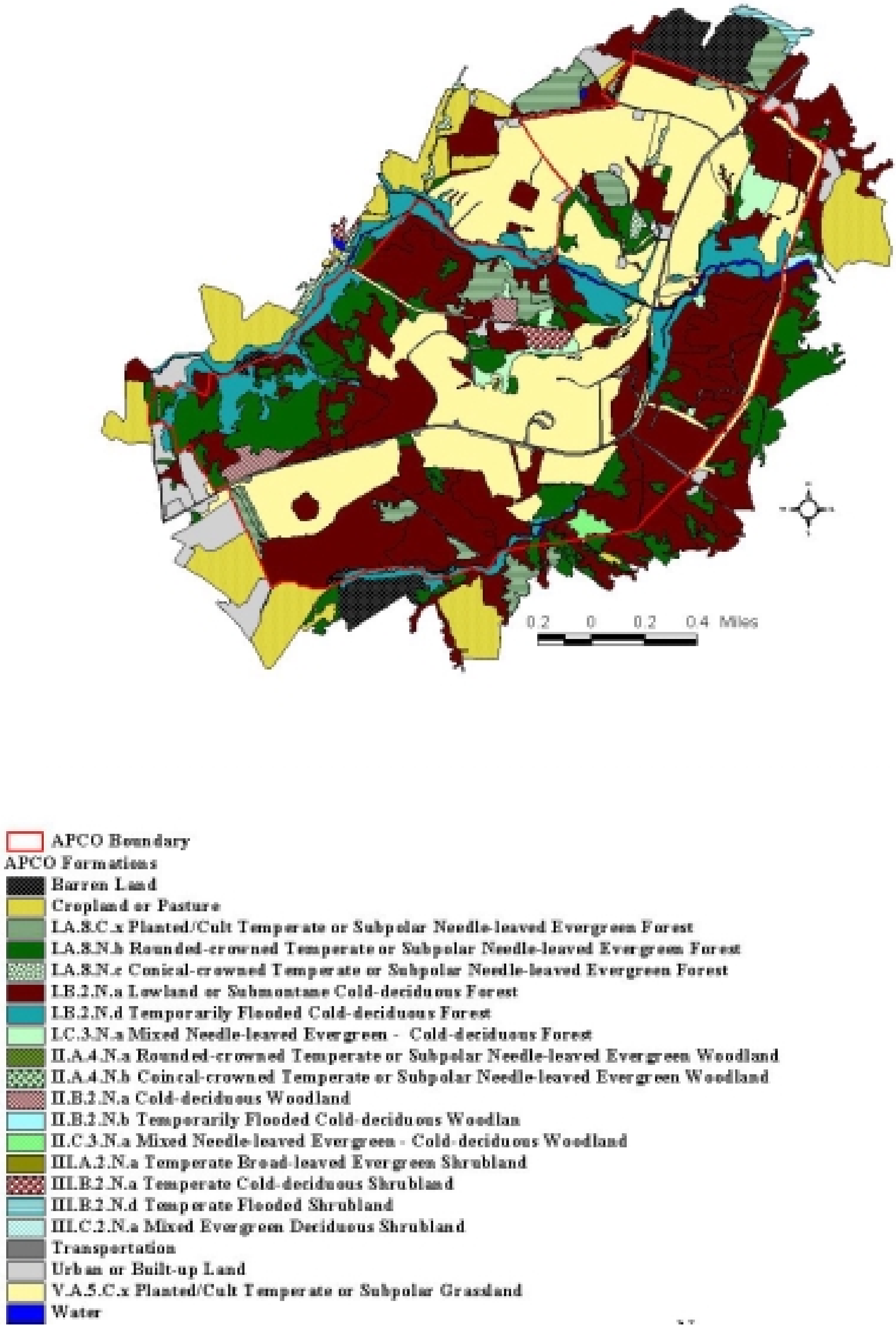

Figure 11. Revised Appomattox Court House formation vegetation map with legend.

6. Discussion

6.1 Evaluation of mapping process

6.1.1 Ground Control

By increasing the amount of ground control for the Appomattox photography, the length of time for this study could be decreased. Three to four weeks passed as up to 220 GCPs were added to aid in the triangulation process with all fifty photographs. Identifiable points between the DOQQ and photographs were difficult to discern because most land around the park is in forestry or agriculture, with few discrete points available for ground control locations. The Erdas Orthobase Field Guide suggested adding GPS-collected points spaced strategically over the photographs to deal with this solution-finding problem. In February 2001, 36 GCPs were manually taken at Appomattox Court House and added to the Orthobase formula, but did not produce a solution. Using different combinations of Orthobase blunder checking and methods of compensating for errors in the photography in the triangulation software, unacceptable solutions with high error were reached. The reports that came with these solutions, however, were useful in figuring other sources of error besides the GCPs. Several photos on the ends of the flight lines had very distorted Kappa and Gamma values. Distributing more GCPs on these photos did not reduce these exterior orientation errors. An acceptable solution was finally reached with a combination of GCPs and by subtracting the aerial photos at the end of flight lines with rotation errors.

6.1.2 Mapping Time

Once the photo block was constructed with an acceptable rate of error (below one meter in the X- and Y- directions, less than two meters vertically), the mapping process progressed quickly. With the block constructed, stereo viewing was immediately possible through Stereo Analyst, and delineation began the day after triangulation. The actual stand delineation for the park's 1,743 acres was completed over seven working days, five of those being for stand delineation. The last two days provided time for line editing and revision. Classification took five full working days working in ArcView. Accuracy assessment preparation required four to five eight-hour days, and then the assessment project itself was a seven-day field venture at the park. Without the ground control problems experienced early on in research, the mapping process could have easily been reduced from four months to approximately three.

Stereo Analyst proved a valuable classification tool. It enabled the interpretation of patterns in tree stands and land-cover and their delineation at the same time, the interpreter being able to save the changes and corrections as work progressed. The stereo viewing made possible was equal to the quality provided by manual stereoscopes with printed photos, and was more maneuverable in that the interpreter could change the viewing scale. The Stereo Analyst portion of this study makes this project an entirely digital protocol for vegetation mapping that meets the USGS-NPS accuracy standards.

Vegetation mapping has evolved from groundwork, to the use of aerial photography, to now more digital, computer-based analysis methods. With each change have come advances in collecting more data over less time. Millinor's technique of manual stereo viewing with digital delineation took approximately 200 hours, as compared to similar past studies without digital delineation that took 675 hours using a zoom transfer scope (Millinor, 2000). Stereo delineation in this project took 60 hours, with increased thematic accuracy. Excluding the ground control problem mentioned above, a formation level vegetation map was produced in just over three months, or approximately 500 hours, from the photography scanning to map revision.

6.2 Accuracy

6.2.1 Time Lapse

Time lag between imagery acquisition and the ground truthing aspect of mapping effects the thematic accuracy of the vegetation recorded within a plot (National Biological Service/ National Park Service, 1994). Areas that are extremely affected by human and/or other environmental impacts, thus having difficult cover to classify to currently existing categories, can also hinder accuracy assessment. With proper measurement and vegetation training, individuals performing ground truthing can become more consistent. Timely ground assessment is difficult simply because of the time needed for interpretation. Five months elapsed between data acquisition and ground truthing for this study, and just over three months is achievable. More representative classes being in place can only be helped with further NVCS use and study.

6.2.2 GPS

A source of error thematically came from a well-known limitation of GPS: satellite reception problem beneath tree cover. Several points that were classified on the map as *Pinus virginiana* Forest alliance were thought to actually be hardwood on the ground after exhaustive signal and map searching, but still probably did not fall within the intended 20-meter plot area. A range pole was used on one day of assessment, but did not seem to appreciably increase signal reception over the eight hours of data collection, and impeded movement through the thick brush. There is no readily available solution to this GPS reception problem, but this limitation should be considered when planning field assessment. A recent study comparing the performance of the Trimble ProXR, a unit similar to the ProXRS used at ACHNHP, to four other

GPS units under a forest canopy indicated that the ProXR gave the best results overall of the five receivers tested (Karsky et al., 2000). A Rockwell PLGR-96 performed better under a dense canopy than most of the C/A code receivers, but data collection was more complicated than with the ProXR. This unit, though, is a possible alternative for use with plots that fall under dense canopy. The Trimble ProXRS took a length of time to acquire points in the field beneath well-developed canopy due to the receiver mask settings of precision dilution of precision (PDOP), signal-to-noise ratio (SNR), and elevation angle. This slowed fieldwork and led to poor point location for points beneath thicker canopy due to the ProXRS giving contradictory positions and waypoint navigation due to the masks slowing satellite signal capture and interpretation. These masks, however, insure that the receiver logs the accurate positions.

For positional accuracy assessment, acquiring better points would have probably been possible with several more days in the field, planning for the maximum number of satellites on a clear day. Rain was prevalent the last three days of data collection, though the radio link reception only seemed problematic on two points instead of the nine that were identified after downloading the GPS points. Cloud cover affects the reliability of GPS and radio link reception, causing the signals to bounce around and reach the receiver from the wrong angle or not reach it at all.

6.2.3 Map Registration Error

A problem, noted in the NBS/NPS Accuracy Assessment Procedures, which probably influenced thematic accuracy in this study, was error due to distortions introduced by map registration error (National Biological Service/ National Park Service, 1994). The DEM and DOQQs are both required to have an RMSE of no greater than 7.0 meters (USGS [3], 1995).

The errors in these references produce error in the product created from them. In the created products, a majority of the map positions should be registered to the true ground coordinates with the procedures used here. Some areas, however, are probably not exact positions due to Erdas Orthobase triangulating a solution for the entire block. With this solution, there is the chance some points are estimated incorrectly.

6.2.4 Locating Landmarks for Positional Accuracy Assessment

Checking positional accuracy was complicated by the inability to locate well defined landmarks on the aerial images due to the agricultural and forested nature of Appomattox Court House. Forty-six points were recorded using real-time corrected GPS in the field, but only 37 points had enough corrected positions from adequate radio-link reception. The spread of points correlated highly with the local road network and does not give the coverage of positional information desired.

Throughout the mapping process, care was taken to assure acquisition of the best data available, to perform uniform data conversion, and attention given to careful photo interpretation to insure the least amount of error possible was included in the final products. However, in such methods of land characterization, such mapping will always fall short of being a precise exercise in scientific measurement, despite the availability of remote sensing (Goodchild, 1994). Because the fields of GIS and remote sensing create approximations of geographical space, issues of error and uncertainty are critical to successful integration. Most in the geographic information community realize that the digital generalization process required to represent features is still problematic, and that research needs to develop methods for data abstraction and data reduction that keep track of data quality (Ahiqvist *et al.*, 2000). Accuracy should be a driving factor behind advances in digital photogrammetry and stereo-viewing research.

6.3 Misclassifications

Mistaking the Lowland or Submontane Cold-deciduous Forest formation for a Temporarily Flooded Cold-deciduous Forest and planted pine for natural pine forest were the main classification errors. The temporarily flooded forest decisions were made based

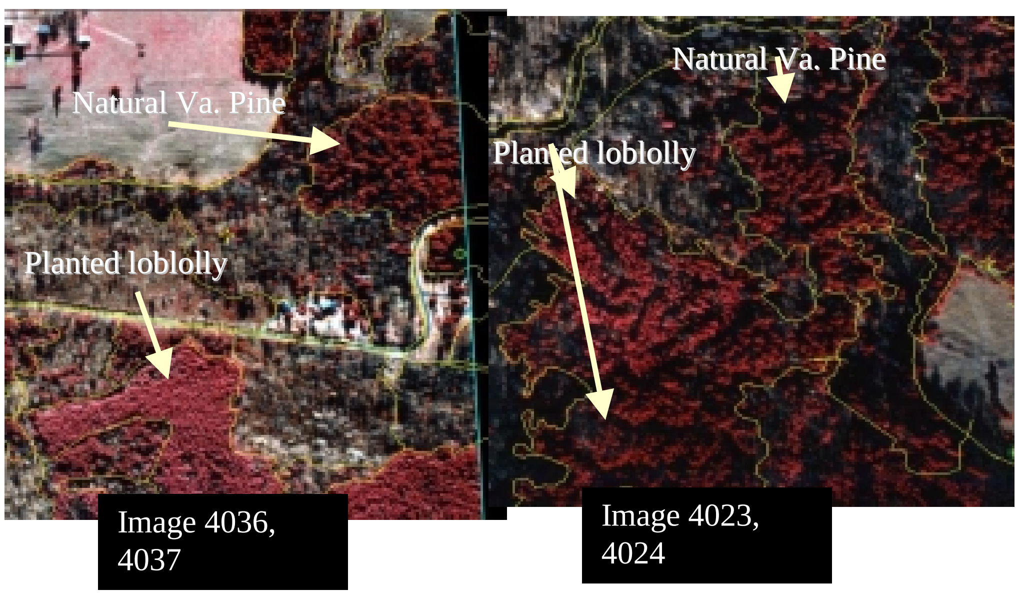

Figure 12. Planted pine compared to natural pine in aerial imagery.

on stereo viewing of ground slope and aspect compared to surrounding land and visibility of drainages. Forested areas around the North Branch of the Appomattox River and Plain Run Branch that appeared relatively flat in Stereo Analyst were assigned to the Temporarily Flooded Forest formation. The areas were usually narrow and comprised almost completely of deciduous trees. The upland areas of the park tend to have a significant pine component in the north and southwestern portions of the park, with hardwoods almost exclusively occurring around drainages. This pattern is due to most upland land being in agriculture before 1950. These areas are now in different stages of succession, indicated by the prevalent number of *Pinus virginiana* stands at Appomattox.

Young *Pinus virginiana* grows in tight stands, and these stands were misinterpreted as planted loblolly, the other significant pine component of Appomattox Court House. *Pinus taeda* is not a county native, but grows well in this upper Piedmont soil, and is the principal planted tree in the central Virginia area (Virginia Department of Forestry, 2000). Former landowners that have now sold their holdings to the park planted loblolly, explaining current stands found near the north central area of the park. Loblolly is maintained as a planted screen to other forestry practices just outside the north boundary of the park on Virginia Primary Highway 24. These different stands have obvious rows and tight, round crowns. Spectral inconsistency among the aerial photos was the main reason for the misclassification of natural stands as planted stands. Baker et al. recognized the difficulty of using scanned aerial photographs for change research, explaining that each photo has a different spectral representation of the same features as the light conditions and the position of the camera change from photograph to photograph. Holopainen and Wang (1998) cite similar spectral problems, pointing out that aerial cameras record a photograph from the central position, causing differential shading. This shading causes bi-directional reflectance, which is especially harmful to fine-resolution, low-altitude airborne imaging. Bi-directional reflectance can be observed through variations in brightness, causing the same forest type to have completely different reflectance values depending on its position in the photograph. An interpreter for vegetation imagery must keep these points in mind when classifying multiple photos, but when working with smaller scale imagery, can employ spectral values as a decision-making tool.

There was 100 percent omission error in six classes, but the Cold-deciduous Shrubland Formation had a total four omissions making it the most significant. Misclassification of this category is a result of the goal to “map existing vegetation”. In Stereo Analyst, the density and texture of these polygons was not tall enough to classify as shrubland. As the accuracy assessment was five months after the photography and well into spring, ten to 12-foot vegetation had time to grow and become a different NVCS class. The polygons were thus different on the imagery than they were in reality, causing the interpreter to omit these polygons from the shrubland formation classes. The majority of the other omissions are based on this same difference in height between December and May. Mapping existing vegetation by the aerial photography then doing ground assessment several months later produces a difference in the classified and actual vegetation due to time lag. The interpreter may hypothesize that an area is simply a successional stage of a forest type and is most correctly classified by the forest type, but the height or canopy closure omits this stand from initial inclusion of the forest type because of the USGS-NPS instructions to map the existing vegetation, not what the vegetation may become. Upon field assessment, the polygon may be the forest type due to growth between data acquisition and accuracy assessment, decreasing thematic accuracy.

8. Recommendations

8.1 Future Study

Using airborne GPS while flying the photo mission may alleviate the ground control problems encountered in this study by providing ground control reference with the photography. If performing another study over a rural park like Appomattox Court House, this would be a good study piece for perfecting ground control in large-scale vegetation mapping.

As this study was in the preparation stages, valuable ancillary data from VPI's 1986 Forest Management Plan added to the knowledge of the Appomattox study site. It provided a groundwork map constructed as a result of contemporary stand delineations, species compositions, and a prediction of the stand composition over the next 50 years. As research proceeded, George Ahles, restoration gardener at the park passed along an 1865 base map from the US Department of the Interior. It provided a perspective of a less-forested Appomattox Court House due to the intense farming of the Southeast prior to the Civil War period. Roy Moon of Appomattox supplied a third piece of information, a 1960s black-and-white aerial photograph of much of the main park unit. These pieces of information with this current vegetation map supply good information for a change study of the park area. Perhaps a viable seedbed for area species may be identified that does not appear to have been disturbed over the time of the data in hand. The data gathered could possibly aid the park in locating dig sites for the current archeological studies in conjunction with area researchers. This information is valuable for park planners as they attempt to manage the current land resources and look to future uses.

8.2 Further NVCS Development

The NVCS system is still in the process of being developed. More successional categories must be developed to correctly characterize the current vegetation of the US, especially in the diverse Southeast. The growth of ecology as a science in the last century has led to increased understanding that a great portion of Southeastern forested areas are second-growth (Wentworth, 2001). With this understanding, NHPs, mappers, and local ecologists need to work together to get these successional forest definitions in place. Frank Koch's creation of the draft alliance map for Valley Forge produced six new alliances that are now being evaluated by the Pennsylvania Natural Diversity Inventory, a TNC affiliate that is Pennsylvania's equivalent agency to the NHP (Koch, 2001). Several of these alliances are invasive, and, if approved, will aide in defining natural vegetation in Pennsylvania and neighboring states with similar species compositions.

8.3 Employing Ancillary Data

Appomattox Court House had VPI's 1986 Forest Management Study available for this study, which contained predecessory information that aided in predicting the present NVCS classes in the park. This information, though not covering the full park holdings to date, gave the interpreter a picture of the landscape 15 years before the current aerial photography. This allowed prediction of alliance levels (though not tested with an accuracy assessment in this study) to aide the future Virginia NHP investigation. VPI used the Society of American Foresters (SAF) classification for this study, and the unit names aided the interpreter in assessing possible alliances present when doing ground truthing. Researchers should do a thorough search for ancillary information before building a product with classification to have the maximum amount of information for making NVCS classification decisions.

9. References

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Table 9. Exterior orientation parameters for each image as estimated by aerial triangulation.

image ID	Xs	Ys	Zs	OMEGA	PHI	KAPPA
41	697549.24	4140421.6	1133.8868	1.9214	-0.7184	2.2826
23	696913.44	4139450.5	1144.4859	-0.6833	-0.4634	184.8685
40	697034.15	4140398.5	1131.8418	2.4374	0.8974	1.5715
44	697042.53	4141364.5	1145.697	-0.7268	-0.9864	183.5299
2	696716.04	4137520	1134.3484	-0.9175	-0.7135	183.7565
24	696393.38	4139440.2	1142.7012	-0.6664	-0.3167	184.8907
39	696510.24	4140399	1139.0551	1.4251	1.1147	1.4095
45	696508.09	4141365.7	1140.8723	-0.9242	-0.1895	183.9283
3	696177.98	4137513.1	1131.0948	-1.056	-0.1531	184.1267
19	696103.14	4138462.7	1137.418	1.6558	0.5299	1.2139
25	695844.14	4139424.3	1142.8441	-1.1243	0.1126	184.9577
38	695944.22	4140392.4	1144.4357	2.4915	0.3585	0.241
46	695985.56	4141364.6	1134.4914	-0.7053	-0.2349	185.2655
4	695658.06	4137502	1129.7316	-1.3278	0.1278	185.3246
18	695550.73	4138447.7	1139.3461	2.2397	-0.1159	0.7662
26	695319.08	4139413.2	1143.152	-0.7618	0.2257	184.6554
37	695406.04	4140382.2	1151.5526	1.5869	0.1884	-0.2584
47	695433.74	4141352.7	1134.5476	-1.4417	0.1102	185.2189
5	695109.66	4137489.8	1131.864	-1.5765	0.2547	184.8957
17	695027.61	4138433.7	1139.6775	1.412	-0.015	1.4855
27	694772.61	4139400.9	1144.5659	-1.5368	0.0628	184.2898
36	694879.99	4140362.4	1158.7303	1.2142	0.7606	0.9587
48	694906.23	4141335.7	1134.9142	-0.8331	0.3166	185.1046
6	694566	4137485.5	1127.3223	-1.9609	0.1802	185.1329
16	694477.66	4138416.3	1140.455	2.3112	-0.6111	2.0272
28	694247.22	4139389.9	1143.4116	-0.7212	-0.4264	185.0458
35	694334.83	4140323.5	1153.8326	1.0541	-1.178	2.0171
49	694372.77	4141321.7	1132.4612	-0.4788	-0.317	185.5212
7	694041.7	4137467.6	1126.8042	-1.5298	0.0354	184.8525
15	693929.55	4138399.7	1137.7203	2.1144	-0.6751	2.6074
29	693693.58	4139379.9	1141.5892	-0.7217	-0.2103	185.6511
34	693814.7	4140304	1149.5605	1.6638	-0.5289	2.4925
8	693493.04	4137453.1	1125.5547	-1.1072	-0.3728	185.6829
14	693399.36	4138389.5	1138.5759	1.7297	-0.089	2.6556
30	693178.22	4139364.7	1141.8708	-0.8155	0.2579	185.5737
9	692993.62	4137434	1123.1301	-1.0365	-0.4364	185.7923
13	692876.07	4138376.9	1142.2736	2.0815	0.3568	1.9387
31	692619.66	4139355.9	1145.4854	-1.2889	-0.4226	185.2081
12	692348.81	4138367.5	1143.9653	2.2021	0.1127	1.2567

APPENDICES

APPENDIX A. NSE DEM Preparation Commands in ArcInfo GRID

After the data was extracted from the zipped file with Winzip, the following commands were used in ArcInfo 7.2.1 to project the NSE grid from the USGS for the designated area of Appomattox County, Virginia:

Grid: ACHNHP = projectgrid (demgrid)

****
***   The INPUT projection has been defined.   ***
****

Use OUTPUT to define the output projection and END to finish.

Project: output

Project: projection utm

Project: datum nad83

Project: units meters

Project: zunits meters

Project: parameters

Project: end

To resample the DEM to 10 meters, the following commands were used in ArcInfo 7.2.1:

Grid: ACHNHP_10m = resample(demgrid, 10, cubic)

APPENDIX B. Vegetation Line Shape File Conversion to Polygon Shape File Preparation Commands in ArcInfo

The following commands were used in ArcInfo 7.2.1 to convert the line shape file theme delineating vegetation stands created in Erdas Stereo Analyst to a polygon coverage:

Arc: shapearc veg_lines.shp veg_polys

Arc: clean veg_polys # # # poly

Arc: build veg_polys poly

The coverage was then opened in ArcView 3.2 as a coverage, made the active theme, and then converted to a shape file to be compatible with the ACHNHP GIS.
(Note: ArcInfo 8.0 is a viable alternative to the command line approach, but did not as consistently execute commands as the command line version of ArcInfo as the ACHNHP vegetation mapping project was being performed.)

APPENDIX C. Erdas Orthobase Photo Mosaic Metadata

Identification_Information:
  Citation:
    Citation_Information:
      Originator: North Carolina State University, Center for Earth Observation
      Publication_Date: 20000622
      Title: Imagine .img file color infrared image of Appomattox Court House National Historical Park
      Edition: first
      Geospatial_Data_Presentation_Form: map
  Description:
    Abstract:
      Orthorectified color infrared Imagine image of Appomattox Court House National Historical Park and surrounding parcels. Produced from 50 color infrared photos taken December 18, 2001 in leaf-off conditions.
    Purpose:
      The dataset was developed for use by Appomattox Court House National Historical Park to allow better resource management and park planning.
  Time_Period_of_Content:
    Time_Period_Information:
      Single_Date/Time:
        Calendar_Date: 20001218
        Time_of_Day: 1300
    Currentness_Reference: ground condition
  Status:
    Progress: Complete
    Maintenance_and_Update_Frequency: Unknown
  Spatial_Domain:
    Bounding_Coordinates:
      West_Bounding_Coordinate: -78.8312
      East_Bounding_Coordinate: -78.7715
      North_Bounding_Coordinate: 37.4009
      South_Bounding_Coordinate: 37.3569
  Keywords:
    Theme:
      Theme_Keyword_Thesaurus: none
      Theme_Keyword: Imagine
      Theme_Keyword: Erdas Orthobase
      Theme_Keyword: Color Infrared
      Theme_Keyword: mosaic
      Theme_Keyword: aerial photo
      Theme_Keyword: photo mosaic
      Theme_Keyword: digital photogrammetry
      Theme_Keyword: softcopy photogrammetry

    Place:
      Place_Keyword_Thesaurus: none
      Place_Keyword: Virginia
      Place_Keyword: Historical Park
      Place_Keyword: National Park
      Place_Keyword: Appomattox Court House National Historical Park
      Place_Keyword: Appomattox
    Temporal:
      Temporal_Keyword_Thesaurus: none
      Temporal_Keyword: 2000
      Temporal_Keyword: leaf-off
      Temporal_Keyword: December
  Access_Constraints: none
  Use_Constraints: none
  Point_of_Contact:
    Contact_Information:
      Contact_Person_Primary:
        Contact_Person: Chief of Maintenance
        Contact_Organization: Appomattox Court House National Historical Park
      Contact_Position: Chief of Maintenance
      Contact_Address:
        Address_Type: mailing address
        Address:
          Chief of Maintenance
          Appomattox Court House National Historical Park
          Hwy. 24, P.O. Box 218
        City: Appomattox
        State_or_Province: Virginia
        Postal_Code: 24522
        Country: USA
      Contact_Voice_Telephone: (804) 352-8987 ext. 28
      Contact_Facsimile_Telephone: (804) 352-8330
      Contact_Electronic_Mail_Address: roger_firth@nps.gov
  Data_Set_Credit: Melani Harrell, NCSU-CEO
  Native_Data_Set_Environment:
    Windows NT Version 4.0 (Build 1381) Service
    Pack 6; ESRI ArcInfo 7.2.1, Erdas Orthobase 8.4.
Data_Quality_Information:
  Logical_Consistency_Report: none
  Completeness_Report: Appomattox Court House National Historical Park
  Positional_Accuracy:
    Horizontal_Positional_Accuracy:
      Horizontal_Positional_Accuracy_Report:
        0.603 meters in the x direction
        2.415 meters in the y direction

Class 2 map accuracy
Horizontal accuracy was found by assessing 39 points in the field
spread throughout the orthorectified image area. These points
were identified on the base map and then were found in the field
where their coordinates were taken using a Trimble ProXRS
with real time data correction. The field coordinates were then
compared to the coordinates from the base map in ArcView 3.2
to determine positional accuracy.
Lineage:
Source_Information:
Source_Citation:
Citation_Information:
Originator: Air Photographics, Inc
Publication_Date: Unpublished Material
Title: Aerial photographs of the Appomattox Court House National Historical Park
Edition: first
Geospatial_Data_Presentation_Form: remotely-sensed image
Source_Scale_Denominator: 6000
Type_of_Source_Media: color infrared aerial photographs
Source_Time_Period_of_Content:
Time_Period_Information:
Single_Date/Time:
Calendar_Date: 20001218
Source_Currentness_Reference: ground condition
Source_Citation_Abbreviation: aerial photos
Source_Contribution: Aerial view of Appomattox Court House National Historical Park
Process_Step:
Process_Description:
The aerial photos (42 total) were used to create an orthorectified mosaic
using Erdas Imagine and Erdas Orthobase. The photos were scanned at 600 dpi and imported into
Imagine. They were then orthorectified using four USGS DOQQ's and a USGS National Seamless Elevation
DEM as reference. The DEM was resampled from 30 meters to 10
meters using ArcInfo 7.2.1. Each photo was entered into an Orthobase photo block and registered to its interior orientation. Tie points were applied and automatic tie points generated and control points were applied in the Orthobase Point Measurement Tool. Once a successful triangulation solution was reached in Orthobase, the orthorectified images were then mosaicked within Imagine to form one seamless base map image for Appomattox Court House National Historical Park.
Process_Date: 200104
Process_Contact:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: NCSU, Center for Earth Observation

Contact_Address:
Address_Type: mailing address
Address:
NCSU, Center For Earth Observation
NCSU Campus Box 7106
City: Raleigh
State_or_Province: NC
Postal_Code: 27695-7106
Country: USA
Contact_Voice_Telephone: 919-515-3430
Contact_Facsimile_Telephone: 919-515-3439
Hours_of_Service: 9:30 am - 6:00 pm
Spatial_Data_Organization_Information:
Direct_Spatial_Reference_Method: Raster
Raster_Object_Information:
Raster_Object_Type: Pixel
Row_Count: 18095
Column_Count: 19702
Vertical_Count: 1
Spatial_Reference_Information:
Horizontal_Coordinate_System_Definition:
Planar:
Grid_Coordinate_System:
Grid_Coordinate_System_Name: Universal Transverse Mercator
Universal_Transverse_Mercator:
UTM_Zone_Number: 17
Transverse_Mercator:
Scale_Factor_at_Central_Meridian: 0.999600
Longitude_of_Central_Meridian: -81.000000
Latitude_of_Projection_Origin:
False_Easting: 500000.000000
False_Northing: 0.000000
Planar_Coordinate_Information:
Planar_Coordinate_Encoding_Method: row and column
Coordinate_Representation:
Abscissa_Resolution: 0.173425
Ordinate_Resolution: 0.173425
Planar_Distance_Units: meters
Geodetic_Model:
Horizontal_Datum_Name: North American Datum of 1983
Ellipsoid_Name: Geodetic Reference System 80
Semi-major_Axis: 6378137.000000
Denominator_of_Flattening_Ratio: 298.257222
Entity_and_Attribute_Information:
Overview_Description:

Entity_and_Attribute_Overview: Dataset consists of a raster 3-band color image, each pixel value is between 0-255.
Entity_and_Attribute_Detail_Citation: none

Distribution_Information:
Distributor:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Chief of Maintenance
Contact_Organization: Appomattox Court House National Historical Park
Contact_Position: Chief of Maintenance
Contact_Address:
Address_Type: mailing address
Address:
Chief of Maintenance
Appomattox Court House National Historical Park
Hwy. 24, P.O. Box 218
City: Appomattox
State_or_Province: Virginia
Postal_Code: 24522
Country: USA
Contact_Voice_Telephone: (804) 352-8987 ext. 28
Contact_Facsimile_Telephone: (804) 352-8330
Contact_Electronic_Mail_Address: roger_firth@nps.gov
Resource_Description: Orthorectified 3 band color raster image of Appomattox Court House National Historical Park.
Distribution_Liability:
The National Park Service shall not be held liable for improper or incorrect use of the data described and/or contained herein. These data and related graphics ("TIF" format files) are not legal documents and are not intended to be used as such. The information contained in these data is dynamic and may change over time. The data are not better than the original sources from which they were derived. It is the responsibility of the data user to use the data appropriately and consistent within the limitations of geospatial data in general and these data in particular. The related graphics are intended to aid the data user in acquiring relevant data; it is not appropriate to use the related graphics as data. The National Park Service gives no warranty, expressed or implied, as to the accuracy, reliability, or completeness of these data. It is strongly recommended that these data are directly acquired from an NPS server and not indirectly through other sources which may have changed the data in some way. Although these data have been processed successfully on a computer system at the National Park Service, no warranty expressed or implied is made regarding the utility of the data on another system or for general or scientific purposes, nor shall the act of distribution constitute any such warranty. This disclaimer applies both to individual use of the data and aggregate use with other data.

Custom_Order_Process:
Contact
Head of Maintenance, Roger Firth
Appomattox Court House National Historical Park
PO Box 218
Appomattox, VA 24522
(804) 352-8987 ext. 28
roger_firth@nps.gov
Metadata_Reference_Information:
Metadata_Date: 20010622
Metadata_Contact:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: Center for Earth Observation
Contact_Address:
Address_Type: mailing address
Address:
NCSU, Center For Earth Observation
NCSU Campus Box 7106, 5112 Jordan Hall
City: Raleigh
State_or_Province: NC
Postal_Code: 27695-7106
Country: USA
Contact_Voice_Telephone: 919-515-3430
Contact_Facsimile_Telephone: 919-515-3439
Contact_Instructions: phone
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998
Metadata_Time_Convention: local time

APPENDIX D. Formation Map Metadata

Identification_Information:
  Citation:
    Citation_Information:
      Originator: North Carolina State University, Center for Earth Observation
      Publication_Date: 20010622
      Title: Appomattox Court House National Historical Park Vegetation
      Edition: first
      Geospatial_Data_Presentation_Form: map
  Description:
    Abstract: Vegetation classification of Appomattox Court House National Historical Park. Vegetation was delineated to the formation level using the National Vegetation Classification System developed by The Nature Conservancy and state National Heritage Programs. The minimum mapping unit was 0.5 acre. The data was created following general guidelines set forth by the USGS-NPS Vegetation Mapping Program. The data meets National Map Accuracy Standards for a Class 2 map.
    Purpose: This data set was created for use by Appomattox Court House National Historical Park to aid in development of a general management plan for better resource management and park planning.
  Time_Period_of_Content:
    Time_Period_Information:
      Single_Date/Time:
        Calendar_Date: 20001218
        Time_of_Day: 1300
    Currentness_Reference: Time and data of source photography.
  Status:
    Progress: Complete
    Maintenance_and_Update_Frequency: Unknown
  Spatial_Domain:
    Bounding_Coordinates:
      West_Bounding_Coordinate: -78.8276
      East_Bounding_Coordinate: -78.7727
      North_Bounding_Coordinate: 37.3992
      South_Bounding_Coordinate: 37.3619
  Keywords:
    Theme:
      Theme_Keyword_Thesaurus: none
      Theme_Keyword: nature conservancy
      Theme_Keyword: classification
      Theme_Keyword: USGS
      Theme_Keyword: NPS
      Theme_Keyword: color ir
      Theme_Keyword: color infrared
      Theme_Keyword: Erdas Stereo Analyst

Theme_Keyword: Erdas Orthobase
Theme_Keyword: formation
Theme_Keyword: vegetation mapping
Theme_Keyword: vegetation
Theme_Keyword: land-cover
Place:
Place_Keyword_Thesaurus: none
Place_Keyword: Virginia
Place_Keyword: Historical Park
Place_Keyword: National Park
Place_Keyword: Appomattox
Place_Keyword: Appomattox Court House National Historical Park
Temporal:
Temporal_Keyword_Thesaurus: none
Temporal_Keyword: 2000
Temporal_Keyword: leaf-off
Temporal_Keyword: December
Temporal_Keyword: time-lapse
Access_Constraints: none
Use_Constraints: none
Point_of_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Chief of Maintenance
Contact_Organization: Appomattox Court House National Historical Park
Contact_Position: Chief of Maintenance
Contact_Address:
Address_Type: mailing address
Address:
Chief of Maintenance
Appomattox Court House National Historical Park
Hwy. 24, P.O. Box 218
City: Appomattox
State_or_Province: Virginia
Postal_Code: 24522
Country: USA
Contact_Voice_Telephone: (804) 352-8987 ext. 28
Contact_Facsimile_Telephone: (804) 352-8330
Contact_Electronic_Mail_Address: roger_firth@nps.gov
Data_Set_Credit: Melani Harrell, NCSU-CEO
Native_Data_Set_Environment:
Windows NT Version 5.0 (Build 2195) ; ESRI
ArcInfo 7.2.1, Erdas Orthobase 8.4, Erdas Stereo Analyst.
Data_Quality_Information:
Attribute_Accuracy:

Attribute_Accuracy_Report:
Classified to the formation level of the National Vegetation
Classification System, with 88 percent overall thematic accuracy. Thematic accuracy was
tested using a stratified random sample based on number of polygons per class
and total area per class given by the USGS-NPS vegetation mapping guidelines. 196 of 399 polygons were visited in the field for accuracy assessment. The accuracy assessment procedures followed guidelines of the
USGS-NPS Vegetation Mapping Program.
Logical_Consistency_Report: Arc and polygon topology exists
Completeness_Report: Areas >= 0.5 acres were delineated and classified
Positional_Accuracy:
Horizontal_Positional_Accuracy:
Horizontal_Positional_Accuracy_Report:
Class 2 positional accuracy according to national map accuracy standards
0.603 meters in the x direction
2.415 meters in the y direction
Lineage:
Source_Information:
Source_Citation:
Citation_Information:
Originator: Air Photographics, Inc
Publication_Date: Unpublished Material
Title: Aerial photographs of Appomattox Court House National Historical Park
Edition: first
Geospatial_Data_Presentation_Form: remotely-sensed image
Source_Scale_Denominator: 6000
Type_of_Source_Media: color infrared aerial photographs
Source_Time_Period_of_Content:
Time_Period_Information:
Single_Date/Time:
Calendar_Date: 20001218
Source_Currentness_Reference: ground condition
Source_Citation_Abbreviation: aerial photos
Source_Contribution: Aerial view of Appomattox Court House National Park
Process_Step:
Process_Description:
The aerial photos (42 total) were used to create an orthorectified mosaic
using Erdas Imagine and Erdas Orthobase. The photos were scanned at 600 dpi and imported into
Imagine. They were then orthorectified using four USGS DOQQ's and a USGS National Seamless Elevation
DEM as reference. The DEM was resampled from 30 meters to 10
meters using ArcInfo 7.2.1. Each photo was entered into an Orthobase photo block and registered to its interior orientation. Tie points were applied and automatic tie points generated and control points were applied in the Orthobase Point Measurement Tool. Once a successful

triangulation solution was reached in Orthobase, orthophotos were constructed in the block and the mosaic was constructed in Imagine.
Process_Date: 200104
Source_Produced_Citation_Abbreviation: Orthorectified Imagine image of Appomattox Court House National Historical Park.
Process_Contact:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: NCSU, Center for Earth Observation
Contact_Address:
Address_Type: mailing address
Address:
NCSU, Center For Earth Observation
NCSU Campus Box 7106
City: Raleigh
State_or_Province: NC
Postal_Code: 27695-7106
Country: USA
Contact_Voice_Telephone: 919-515-3430
Contact_Facsimile_Telephone: 919-515-3439
Hours_of_Service: 9:30 am - 6:00 pm
Source_Information:
Source_Citation:
Citation_Information:
Originator: NCSU, Center for Earth Observation
Publication_Date: 20010622
Title: Orthorectified Imagine image of Appomattox Court House National Historical Park.
Edition: first
Geospatial_Data_Presentation_Form: map
Source_Scale_Denominator: 6000
Type_of_Source_Media: remotely-sensed image
Source_Time_Period_of_Content:
Time_Period_Information:
Single_Date/Time:
Calendar_Date: 20001218
Source_Currentness_Reference: ground condition
Source_Citation_Abbreviation: original Imagine photomosaic
Source_Contribution: Mosaicked aerial view of Appomattox Court House National Historical Park.
Process_Step:
Process_Description: Once a successful triangulation solution was reached in Orthobase, the orthorectified images were then viewed on-screen in stereo using Stereo Analyst. The vegetation stands were delineated on-screen and saved in an ArcView line shape file. The shape file was converted to a polygon coverage in ArcInfo, and then to a polygon shape file in ArcView 3.2.

The vegetation polygons were each labeled with an NVCS formation class, or Anderson Level I or II class if polygons were not vegetated. All polygons were assigned a class.
Process_Date: 200104
Source_Produced_Citation_Abbreviation: vegetation polygons
Process_Contact:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: NCSU, Center for Earth Observation
Contact_Address:
Address_Type: mailing address
Address:
NCSU, Center For Earth Observation
NCSU Campus Box 7106
City: Raleigh
State_or_Province: NC
Postal_Code: 27695-7106
Country: USA
Contact_Voice_Telephone: 919-515-3430
Contact_Facsimile_Telephone: 919-515-3439
Hours_of_Service: 9:30 am - 6:00 pm
Contact_Instructions: phone
Spatial_Data_Organization_Information:
Direct_Spatial_Reference_Method: Vector
Point_and_Vector_Object_Information:
SDTS_Terms_Description:
SDTS_Point_and_Vector_Object_Type: GT-polygon composed of chains
Point_and_Vector_Object_Count: 399
SDTS_Terms_Description:
SDTS_Point_and_Vector_Object_Type: Entity point
Point_and_Vector_Object_Count: 399
SDTS_Terms_Description:
SDTS_Point_and_Vector_Object_Type: Label point
Point_and_Vector_Object_Count: 399
Spatial_Reference_Information:
Horizontal_Coordinate_System_Definition:
Planar:
Map_Projection:
Map_Projection_Name: Transverse Mercator
Transverse_Mercator:
Scale_Factor_at_Central_Meridian: 0.9996000
Longitude_of_Central_Meridian: -81.000000
Latitude_of_Projection_Origin:
False_Easting: 500000.000000
False_Northing: 0.000000
Planar_Coordinate_Information:

Planar_Coordinate_Encoding_Method: row and column
Coordinate_Representation:
Abscissa_Resolution: 0.000008
Ordinate_Resolution: 0.000008
Planar_Distance_Units: meters
Geodetic_Model:
Horizontal_Datum_Name: North American Datum of 1983
Ellipsoid_Name: Geodetic Reference System 80
Semi-major_Axis: 6378137.000000
Denominator_of_Flattening_Ratio: 298.257222
Entity_and_Attribute_Information:
Detailed_Description:
Entity_Type:
Entity_Type_Label: apco_veg_l.dbf
Entity_Type_Definition: Shape file Attribute Table
Entity_Type_Definition_Source: None
Attribute:
Attribute_Label: Comments_
Attribute_Definition: Descriptive comments from interpreter for map user
Attribute_Definition_Source: User Defined
Attribute_Domain_Values:
Unrepresentable_Domain: Character field
Attribute:
Attribute_Label: Usnvc_for_
Attribute_Definition: National Vegetation Classification System formation class for polygon
Attribute_Definition_Source: Terrestrial Vegetation of the Southeastern United States, NVCS Classification System
Attribute_Domain_Values:
Unrepresentable_Domain: Character field
Attribute:
Attribute_Label: Possi_all_
Attribute_Definition: Alliance determined by fieldwork or predicted from ancillary data
Attribute_Definition_Source: User Defined from fieldwork, ancillary data
Attribute_Domain_Values:
Unrepresentable_Domain: Character field
Attribute:
Attribute_Label: Perimeter_
Attribute_Definition: Perimeter of polygon
Attribute_Definition_Source: Software computed
Attribute_Domain_Values:
Range_Domain:
Range_Domain_Minimum: 0.000
Range_Domain_Maximum: 14388.468
Attribute:
Attribute_Label: Acres

Attribute_Definition: Acres polygon covers
Attribute_Definition_Source: User Defined
Attribute_Domain_Values:
Range_Domain:
Range_Domain_Minimum: 0.000
Range_Domain_Maximum: 141.009
Attribute:
Attribute_Label: Area_
Attribute_Definition: Area of polygon
Attribute_Definition_Source: Software computed
Attribute_Domain_Values:
Range_Domain:
Range_Domain_Minimum: 0.000
Range_Domain_Maximum: 587539.142
Attribute:
Attribute_Label: Hectares
Attribute_Definition: Hectares polygon covers
Attribute_Definition_Source: User Defined
Attribute_Domain_Values:
Range_Domain:
Range_Domain_Minimum: 0.00
Range_Domain_Maximum: 57.07
Distribution_Information:
Distributor:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Chief of Maintenance
Contact_Organization: Appomattox Court House National Historical Park
Contact_Position: Chief of Maintenance
Contact_Address:
Address_Type: mailing address
Address:
Chief of Maintenance
Appomattox Court House National Historical Park
Hwy. 24, P.O. Box 218
City: Appomattox
State_or_Province: Virginia
Postal_Code: 24522
Country: USA
Contact_Voice_Telephone: (804) 352-8987 ext. 28
Contact_Facsimile_Telephone: (804) 352-8330
Contact_Electronic_Mail_Address: roger_firth@nps.gov
Resource_Description: Vector polygon coverage of Appomattox Court House National Historical Park Vegetation.
Distribution_Liability:

The National Park Service shall not be held liable for improper or
incorrect use of the data described and/or contained herein. These
data and related graphics ("GIF" format files) are not legal documents
and are not intended to be used as such.
The information contained in these data is dynamic and may change over
time. The data are not better than the original sources from which they
were derived. It is the responsibility of the data user to use the data
appropriately and consistent within the limitations of geospatial data in
general and these data in particular. The related graphics are intended
to aid the data user in acquiring relevant data; it is not appropriate to
use the related graphics as data.
The National Park Service gives no warranty, expressed or implied, as to
the accuracy, reliability, or completeness of these data. It is strongly
recommended that these data are directly acquired from an NPS server and
not indirectly through other sources which may have changed the data in some
way. Although these data have been processed successfully on a computer
system at the National Park Service, no warranty expressed or implied is
made regarding the utility of the data on another system or for general or
scientific purposes, nor shall the act of distribution constitute any such
warranty. This disclaimer applies both to individual use of the data and
aggregate use with other data.
Standard_Order_Process:
Digital_Form:
Digital_Transfer_Information:
Format_Name: ARCE
Digital_Transfer_Option:
Online_Option:
Computer_Contact_Information:
Network_Address:
Network_Resource_Name:
Available via ftp from
http:\\www.nps.gov\gis
Fees: none if ftp
Ordering_Instructions:
contact Chief of Maintenance, Appomattox Court House National Historical Park
(804) 352-8987 ext. 28
Fax: (804) 352-8330
roger_firth@nps.gov
Custom_Order_Process:
contact Chief of Maintenance, Appomattox Court House National Historical Park
(804) 352-8987 ext. 28
Fax: (804) 352-8330
roger_firth@nps.gov
Metadata_Reference_Information:
Metadata_Date: 20010622

Metadata_Contact:
  Contact_Information:
    Contact_Organization_Primary:
      Contact_Organization: NCSU - Center for Earth Observation
    Contact_Address:
      Address_Type: mailing address
      Address:
        NCSU, Center For Earth Observation
        NCSU Campus Box 7106
      City: Raleigh
      State_or_Province: North Carolina
      Postal_Code: 27695-7106
      Country: USA
    Contact_Voice_Telephone: 919-515-3430
    Contact_Facsimile_Telephone: 919-515-3439
    Contact_Instructions: phone
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998
Metadata_Time_Convention: local time

APPENDIX E. MrSID Photo Mosaic Metadata

Identification_Information:
  Citation:
    Citation_Information:
      Originator: North Carolina State University, Center for Earth Observation
      Publication_Date: 20010622
      Title: Compressed Mr SID color infrared image of Appomattox Court House National Historical Park
      Edition: first
      Geospatial_Data_Presentation_Form: remotely-sensed image
  Description:
    Abstract:
      Orthorectified color infrared Mr SID image of Appomattox Court House National Historical Park. Produced from 50 color infrared photos taken December 18, 2000 in leaf-off conditions.
    Purpose:
      The dataset was developed for use by Appomattox Court House National Historical Park to allow better resource management and park planning.
  Time_Period_of_Content:
    Time_Period_Information:
      Single_Date/Time:
        Calendar_Date: 20001218
        Time_of_Day: 1300
    Currentness_Reference: ground condition
  Status:
    Progress: Complete
    Maintenance_and_Update_Frequency: Unknown
  Spatial_Domain:
    Bounding_Coordinates:
      West_Bounding_Coordinate: -78.8312
      East_Bounding_Coordinate: -78.7715
      North_Bounding_Coordinate: 37.4009
      South_Bounding_Coordinate: 37.3569
  Keywords:
    Theme:
      Theme_Keyword_Thesaurus: none
      Theme_Keyword: Imagine
      Theme_Keyword: Color Infrared
      Theme_Keyword: mosaic
      Theme_Keyword: image
      Theme_Keyword: aerial photos
      Theme_Keyword: image compression
      Theme_Keyword: Erdas Orthobase
    Place:

Place_Keyword_Thesaurus: none
Place_Keyword: Virginia
Place_Keyword: Appomattox
Place_Keyword: National Park
Place_Keyword: Historical
Temporal:
Temporal_Keyword_Thesaurus: none
Temporal_Keyword: 2000
Temporal_Keyword: leaf-off
Temporal_Keyword: December
Access_Constraints: none
Use_Constraints: none
Point_of_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Chief of Maintenance
Contact_Organization: Appomattox Court House National Historical Park
Contact_Position: Chief of Maintenance
Contact_Address:
Address_Type: mailing address
Address:
Chief of Maintenance
Appomattox Court House National Historical Park
Hwy. 24, P.O. Box 218
City: Appomattox
State_or_Province: Virginia
Postal_Code: 24522
Country: USA
Contact_Voice_Telephone: (804) 352-8987 ext. 28
Contact_Facsimile_Telephone: (804) 352-8330
Contact_Electronic_Mail_Address: roger_firth@nps.gov
Data_Set_Credit: Melani Harrell, NCSE-CEO
Native_Data_Set_Environment:
Windows NT Version 5.0 (Build 2195) ; ESRI
ArcInfo 7.2.1, Erdas Orthobase 8.4, MrSID.
Data_Quality_Information:
Logical_Consistency_Report: none
Completeness_Report: Appomattox Court House National Historical Park
Positional_Accuracy:
Horizontal_Positional_Accuracy:
Horizontal_Positional_Accuracy_Report:
0.603 meters in the x direction
2.415 meters in the y direction
Class 2 map accuracy
Horizontal accuracy was found by assessing 39 points in the field

spread throughout the orthorectified image area. These points
were identified on the base map and then were found in the field
where their coordinates were taken using a Trimble ProXRS
with real time data correction. The field coordinates were then
compared to the coordinates from the base map in ArcView 3.2 to determine positional accuracy.

Lineage:
Source_Information:
Source_Citation:
Citation_Information:
Originator: Air Photographics, Inc
Publication_Date: Unpublished Material
Title: Aerial photographs of Appomattox Court House National Historical Park
Edition: first
Geospatial_Data_Presentation_Form: remotely-sensed image
Source_Scale_Denominator: 6000
Type_of_Source_Media: color infrared aerial photographs
Source_Time_Period_of_Content:
Time_Period_Information:
Single_Date/Time:
Calendar_Date: 20011218
Source_Currentness_Reference: ground condition
Source_Citation_Abbreviation: aerial photographs
Source_Contribution: Aerial view of Appomattox Court House National Historical Park
Process_Step:
Process_Description:
The aerial photos (42 total) were used to create an orthorectified mosaic
using Erdas Imagine and Erdas Orthobase. The photos were scanned at 600 dpi and imported into
Imagine. They were then orthorectified using four USGS DOQQ’s and a USGS National Seamless Elevation
DEM as reference. The DEM was resampled from 30 meters to 10
meters using ArcInfo 7.2.1. Each photo was entered into an Orthobase photo block and registered to its interior orientation. Tie points were applied and automatic tie points generated and control points were applied in the Orthobase Point Measurement Tool. Once a successful triangulation solution was reached in Orthobase, the orthorectified images were then mosaicked within Imagine to form one seamless base map image for Appomattox Court House National Historical Park. Multi-Resolution Seamless Image Database (MrSID) software was then used to compress the mosaicked image from 1.08 gigabytes to 39.00 megabytes.

Process_Date: 20010622
Source_Produced_Citation_Abbreviation: Orthorectified Imagine image of Appomattox Court House National Park.
Process_Contact:
Contact_Information:
Contact_Organization_Primary:

Contact_Organization: NCSU, Center for Earth Observation
Contact_Address:
Address_Type: mailing address
Address:
NCSU, Center For Earth Observation
NCSU Campus Box 7106
City: Raleigh
State_or_Province: NC
Postal_Code: 27695-7106
Country: USA
Contact_Voice_Telephone: 919-515-3430
Contact_Facsimile_Telephone: 919-515-3439
Hours_of_Service: 9:30 am - 6:00 pm
Source_Information:
Source_Citation:
Citation_Information:
Originator: NCSU, Center for Earth Observation
Publication_Date: 20010622
Title: Orthorectified Imagine image of Appomattox Court House National Park.
Edition: first
Geospatial_Data_Presentation_Form: map
Source_Scale_Denominator: 6000
Type_of_Source_Media: remotely-sensed image
Source_Time_Period_of_Content:
Time_Period_Information:
Single_Date/Time:
Calendar_Date: 20001218
Source_Currentness_Reference: ground condition
Source_Citation_Abbreviation: original Imagine photomosaic
Source_Contribution: The original uncompressed Imagine photomosaic.
Process_Step:
Process_Description:
The Imagine file was exported to a geotiff using Imagine.
A geotiff world file was then created in notepad. Mr SID was then used at a
20:1 compression ratio to compress the image from 1.08gb to 39.00 mb.
Process_Date: 200005
Process_Contact:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: NCSU, Center for Earth Observation
Contact_Address:
Address_Type: mailing address
Address:
NCSU, Center For Earth Observation
NCSU Campus Box 7106

City: Raleigh
State_or_Province: NC
Postal_Code: 27695-7106
Country: USA
Contact_Voice_Telephone: 919-515-3430
Contact_Facsimile_Telephone: 919-515-3439
Hours_of_Service: 9:30 am - 6:00 pm
Contact_Instructions: phone
Spatial_Data_Organization_Information:
Direct_Spatial_Reference_Method: Raster
Raster_Object_Information:
Raster_Object_Type: Pixel
Row_Count: 18095
Column_Count: 19702
Vertical_Count: 1
Spatial_Reference_Information:
Horizontal_Coordinate_System_Definition:
Planar:
Grid_Coordinate_System:
Grid_Coordinate_System_Name: Universal Transverse Mercator
Universal_Transverse_Mercator:
UTM_Zone_Number: 17
Transverse_Mercator:
Scale_Factor_at_Central_Meridian: 0.999600
Longitude_of_Central_Meridian: -81.000000
Latitude_of_Projection_Origin:
False_Easting: 500000.000000
False_Northing: 0.000000
Planar_Coordinate_Information:
Planar_Coordinate_Encoding_Method: row and column
Coordinate_Representation:
Abscissa_Resolution:
Ordinate_Resolution:
Planar_Distance_Units: meters
Geodetic_Model:
Horizontal_Datum_Name: North American Datum of 1983
Ellipsoid_Name: Geodetic Reference System 80
Semi-major_Axis: 6378137.000000
Denominator_of_Flattening_Ratio: 298.257222

Entity_and_Attribute_Information:
Overview_Description:
Entity_and_Attribute_Overview: Dataset consists of a raster 3-band color image, each pixel value is between 0-255.
Entity_and_Attribute_Detail_Citation: none

Distribution_Information:
  Distributor:
    Contact_Information:
      Contact_Person_Primary:
        Contact_Person: Chief of Maintenance
        Contact_Organization: Appomattox Court House National Historical Park
      Contact_Position: Chief of Maintenance
      Contact_Address:
        Address_Type: mailing address
        Address:
          Chief of Maintenance
          Appomattox Court House National Historical Park
          Hwy. 24, P.O. Box 218
        City: Appomattox
        State_or_Province: Virginia
        Postal_Code: 24522
        Country: USA
      Contact_Voice_Telephone: (804) 352-8987 ext. 28
      Contact_Facsimile_Telephone: (804) 352-8330
      Contact_Electronic_Mail_Address: roger_firth@nps.gov
  Resource_Description: Mr. SID image of Imagine .img file color infrared image of Appomattox Court House National Historical Park
  Distribution_Liability:
    The National Park Service shall not be held liable for improper or incorrect use of the data described and/or contained herein. These data and related graphics ("GIF" format files) are not legal documents and are not intended to be used as such.
    The information contained in these data is dynamic and may change over time. The data are not better than the original sources from which they were derived. It is the responsibility of the data user to use the data appropriately and consistent within the limitations of geospatial data in general and these data in particular. The related graphics are intended to aid the data user in acquiring relevant data; it is not appropriate to use the related graphics as data.
    The National Park Service gives no warranty, expressed or implied, as to the accuracy, reliability, or completeness of these data. It is strongly recommended that these data are directly acquired from an NPS server and not indirectly through other sources which may have changed the data in some way. Although these data have been processed successfully on a computer system at the National Park Service, no warranty expressed or implied is made regarding the utility of the data on another system or for general or scientific purposes, nor shall the act of distribution constitute any such warranty. This disclaimer applies both to individual use of the data and aggregate use with other data.

Custom_Order_Process:
Contact
Natural Resource Specialist
Appomattox Court House National Historical Park
PO Box 218
Appomattox, VA 24522
(804) 352-8987 ext. 28
roger_firth@nps.gov
Metadata_Reference_Information:
Metadata_Date: 20011218
Metadata_Contact:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: Center for Earth Observation
Contact_Address:
Address_Type: mailing address
Address:
NCSU, Center For Earth Observation
NCSU Campus Box 7106
City: Raleigh
State_or_Province: NC
Postal_Code: 27695-7106
Country: USA
Contact_Voice_Telephone: 919-515-3430
Contact_Facsimile_Telephone: 919-515-3439
Contact_Instructions: phone
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998
Metadata_Time_Convention: local time

APPENDIX F. NVCS Formations, Alliances, and Descriptions Identified at Appomattox Court House National Historical Park

I.A.8.C.x PLANTED/CULTIVATED TEMPERATE OR SUBPOLAR NEEDLE-LEAVED EVERGREEN

***PINUS TAEDA* PLANTED FOREST ALLIANCE:** Plantations of *Pinus taeda* with little understory. Stands usually have a well-developed understory with mixture of native and exotic species. The midstory may include *Cornus florida*, *Aralia spinosa*, *Sassafras albidum*, and various native *Quercus* species (*falcate, coccinea, stellata*, *marilandica, velutina*) in drier plots and *Acer ruburm*, *Liquidambar styraciflua*, and *Quercus phellos* in wetter plots. The ground layer is usually dense with a high diversity of *Sacchurum alopecuroides*, *Polystichum acrostichoides*, *Eupatorium spp*., *Solidago spp*., *Tephrosia virginiana*, *Rubus spp*., *Desmodium spp*., *Lespedeza spp.*, *Schizachyrium scoparium*, *Aster dumosus*, *Elephatnopus tomentosa*, and *Andropogon gyrans*. Stands which did not have oaks removed at establishment will exhibit a greater density f oaks. Continued natural succession in these stands may lead to a condition where oaks co-dominate in the canopy with *Pinus taeda*. Mixed oak-pine forests appears to be rare at Arnold Air Force Base, Tennessee, with this vegetation occurring only as transitional areas between Oak- and Pine-dominated stands.

I.A.8.N.b ROUNDED-CROWNED TEMPERATE OR SUBPOLAR NEEDLE-LEAVED EVERGREEN FOREST

***PINUS VIRGINIANA* FOREST ALLIANCE:** This alliance includes forests dominated by *Pinus virginiana* and occurring in the Piedmont from Pennsylvania south to Alabama, and ranging west into the Appalachians, Ridge and Valley, the Cumberland Plateau, and in scattered locales of the Interior Low Plateau. Forests in this alliance may have admixtures of *Pinus taeda, Pinus echinata*, and/or *Pinus rigida*. These other species, if present, can have canopy coverage between 10 and 50%. This alliance includes both early successional forests resulting from natural or anthropogenic disturbance and natural forests in edaphically extreme situations. Typically, *Pinus virginiana* communities are short-lived as a forest and are more common as woodland communities [see II.C.3.N.a *Pinus (rigida, pungens, virginiana) - Quercus prinus Woodland Alliance (A.677)*]. Associated species vary with the geographic distribution of the alliance. In the Piedmont common associates include *Liquidambar styraciflua, Pinus taeda, Pinus echinata*, and *Quercus* spp., while on extreme sites in the southern Appalachians, *Pinus pungens* and *Pinus rigida* are more typical. In areas with calcareous geology, *Juniperus virginiana* is a typical associate. In many associations, a dense ericaceous shrub stratum is typical and can include species such as *Vaccinium pallidum, Vaccinium stamineum, Vaccinium arboreum, Vaccinium angustifolium, Vaccinium myrtilloides, Gaylussacia baccata, Gaylussacia ursina, Kalmia latifolia, Rhododendron catawbiense*, and *Rhododendron maximum*.

I.A.8.N.c CONICAL-CROWNED TEMPERATE OR SUBPOLAR NEEDLE-LEAVED EVERGREEN FOREST

***JUNIPERUS VIRGINIANA* FOREST ALLIANCE:** Forests in this alliance are strongly dominated by *Juniperus virginiana var. virginiana* on usually high pH, fire-suppressed sites or old fields, but also mature (100+ year) stands, on limestone or chalk, mostly in blacklands, but occasionally on sandstone (Oklahoma). This alliance is most common in old fields and pastures, successional cleared land, and other various disturbed areas, especially on calcareous rocks. The growth of low *Juniperus virginiana var. virginiana* may be very dense, and the stature may be rather low. In Tennessee examples, other species that may occur in the canopy include *Carya alba, Carya ovata, Cercis canadensis,* and *Pinus virginiana*. Various oaks (including *Quercus coccinea, Quercus falcata*, and *Quercus phellos*) also may be present. The midstory is typically sparse, with canopy species as well as *Cornus florida, Ilex opaca, Liquidambar styraciflua*, and *Prunus serotina var. serotina*. *Frangula caroliniana* may occur in several strata. Herb distribution is patchy, and typical species include *Asplenium platyneuron, Chasmanthium laxum, Eupatorium* spp., *Polystichum acrostichoides*, and *Carex* spp. This vegetation is also found in the Blackbelt of Alabama, on the margins of Chalk Prairies.

I.B.2.N.a LOWLAND OR SUBMONTANE COLD-DECIDUOUS FOREST

***CARYA* (*GLABRA, OVATA*) - *FRAXINUS AMERICANA* - *QUERCUS* (*ALBA, RUBRA*) FOREST ALLIANCE:** Communities of this alliance include dry, relatively 'rich' forests dominated by *Quercus* species and include *Carya* species as a prominent (rarely codominant) feature. *Fraxinus americana*, although sometimes a sporadic member, is generally characteristic of these forests. Associated canopy species include *Quercus alba, Quercus velutina, Quercus rubra, Carya ovalis, Carya glabra*, as well as other oaks and hickories. Communities of this alliance generally occur on dry upper slopes or ridgetops. Soils are usually rich, and may range from slightly acidic to circumneutral pH, on well-drained loams or sandy loams, predominantly on southern or eastern exposures. The shrub layer is usually interrupted to absent. When present, it includes *Viburnum rafinesquianum*, and occasional *Vaccinium* species. *Viburnum acerifolium* is characteristic of some communities of this alliance. Although ericaceous species may be present and occasionally locally abundant, they are not characteristic. The herbaceous layer is characterized by forbs and may be quite diverse. A characteristic sedge is *Carex pensylvanica*. Other forbs found in these communities include *Asplenium platyneuron, Schizachyrium scoparium, Hepatica nobilis var. obtusa (= Hepatica americana), Asclepias quadrifolia, Desmodium* spp., *Arabis canadensis*. The relatively open canopy, sparse shrub layer, and dense herbaceous layer impart a park-like appearance to many of these forests. However, this vegetation is classified as forest rather than woodland because total canopy cover generally exceeds 60%, and few, if any, of the herbs may be thought of as truly shade-intolerant. Those herbs that require high light levels are generally confined to small openings. Portions of SAF type 52, White Oak - Black Oak - Northern Red Oak, are contained within this alliance. These forests are somewhat similar to Braun's (1950) 'oak-hickory forests' of the Midwest. They share many of the same canopy species, and in some cases, similar physiognomy. However, the Oak-Hickory Region of Braun supports forests that occur in close association and intergrade with prairies, and share many of the same species in the herb layer, particularly legumes. For example, *Asclepias verticillata, Lithospermum canescens, Tephrosia virginiana*, *Desmodium* spp., *Euphorbia corollata*, and *Liatris* spp. occur in many of the oak - hickory forests of the Ozark Plateau, and Braun (1950) suggests that they may be remnants of prairie openings invaded by forest. A few outliers of 'Oak - Hickory' forests do occur in the East, however, and these are placed within the *Quercus velutina - Quercus alba - (Quercus coccinea) Forest Alliance (A.1911).*

***FAGUS GRANDIFOLIA - QUERCUS ALBA* FOREST ALLIANCE:** Dry-mesic to mesic forests with admixtures of *Quercus alba* and *Fagus grandifolia* that typically occur on mesic slopes and small stream bottoms in the Coastal Plain, and also in other adjacent physiographic provinces, including the southern part of Crowley's Ridge, Arkansas. This alliance is distributed primarily north of the distribution of *Magnolia grandiflora*. The canopy may include *Liriodendron tulipifera, Liquidambar styraciflua, Quercus michauxii, Quercus pagoda, Carya cordiformis, Fraxinus americana*, and *Ulmus* spp. In the southern part of the range, examples of this alliance may have *Acer barbatum* and *Acer leucoderme* in the subcanopy; other associates may include *Acer rubrum, Carya alba, Carya myristiciformis, Carya ovata, Carya texana, Celtis laevigata, Diospyros virginiana, Fraxinus americana, Gleditsia triacanthos, Gymnocladus dioicus, Juglans cinerea, Liquidambar styraciflua, Morus rubra, Nyssa sylvatica, Prunus serotina var. serotina, Quercus michauxii, Quercus stellata, Ulmus americana, Ulmus alata*, and *Ulmus rubra*. *Magnolia grandiflora* and *Magnolia acuminata* may occur on moister, lower slopes, or in the subcanopy. The total canopy cover is usually dense. *Phoradendron leucarpum, Tillandsia usneoides*, and *Pleopeltis polypodioides ssp. michauxiana (= Polypodium polypodioides var. michauxianum)* may occur as epiphytes on the canopy trees. The understory and tall-shrub strata may include *Aesculus pavia var. pavia, Aralia spinosa, Asimina triloba, Ostrya virginiana, Carpinus caroliniana ssp. caroliniana, Cornus florida, Cercis canadensis, Ilex opaca var. opaca, Styrax grandifolius, Crataegus spathulata*, and *Crataegus marshallii*. The short-shrub stratum, which may vary widely in diversity, may contain *Amelanchier arborea, Callicarpa americana, Chionanthus virginicus, Crataegus marshallii, Frangula caroliniana (= Rhamnus caroliniana), Hydrangea arborescens, Hydrangea quercifolia, Ilex ambigua, Ilex opaca var. opaca, Lindera benzoin, Vaccinium virgatum, Vaccinium arboreum, Vaccinium elliottii, Viburnum acerifolium, Viburnum dentatum*, and *Viburnum rufidulum*; it may be patchy. The herbaceous layer, which is typically sparse, may contain *Athyrium filix-femina ssp. asplenioides, Botrychium* spp., *Diplazium pycnocarpon, Phegopteris hexagonoptera, Osmunda* spp., *Polystichum acrostichoides, Actaea pachypoda, Arisaema triphyllum, Symphyotrichum drummondii (= Aster drummondii), Chasmanthium sessiliflorum, Cynoglossum virginianum, Desmodium nudiflorum, Galium circaezans, Helianthus hirsutus, Lilium michauxii, Lithospermum tuberosum, Maianthemum racemosum, Mitchella repens, Pedicularis canadensis, Podophyllum* *peltatum, Polygonatum biflorum, Scleria oligantha, Smilax herbacea, Smilax pumila, Solidago auriculata, Spigelia marilandica, Tipularia discolor, Tragia cordata, Uvularia perfoliata, Vicia minutiflora*, and *Viola walteri*. This alliance typically occurs on mesic calcareous silty clays, silty loams and silty clay loams, as well as loamy sands or loamy fine sands. This broad-leaved forest is known predominantly from mesic middle and lower slopes; in southeastern Texas it occupies ravines and ridges within creek bottoms. Associated geology includes the Cook Mountain and Jackson formations. In the northwestern part of the range, this association is found on deep loessal soils of Crowley's Ridge, Arkansas (Cross County south through Phillips County), canopies are dominated by *Fagus grandifolia, Quercus alba,* and *Liriodendron tulipifera,* with associates including *Fraxinus americana, Sassafras albidum, Ulmus rubra, Quercus michauxii, Acer saccharum, Magnolia acuminata, Carya illinoinensis*. and *Liquidambar styraciflua*. This alliance concept includes, at least tentatively, forests in Virginia which are dominated by *Fagus grandifolia, Quercus muehlenbergii*, and *Acer barbatum*. Some less diverse examples in the northeastern part of the range, in North Carolina, contain a canopy of *Fagus grandifolia* and *Liquidambar styraciflua* over a subcanopy with *Oxydendrum arboreum* and a (possibly dense) shrub layer of *Kalmia latifolia*. An additional less diverse example in South Carolina contains *Fagus grandifolia, Quercus nigra*, and *Liquidambar styraciflua* as canopy dominants over *Ilex opaca* and a well-developed shrub layer with *Rhododendron canescens, Euonymus americana, Vaccinium elliottii, Symplocos tinctoria, Arundinaria gigantea, Asimina triloba, Callicarpa americana*, and others.

***FAGUS GRANDIFOLIA - QUERCUS RUBRA - QUERCUS ALBA* FOREST ALLIANCE:** Forests in this alliance occur in non-montane or low mountain mesic situations and are dominated by *Fagus grandifolia* with or without some combination of the *Quercus* spp. Associated canopy and subcanopy species can include *Liriodendron tulipifera, Acer saccharum, Magnolia tripetala, Magnolia acuminata* (Ozarks), *Tilia americana* (Ozarks), *Quercus muehlenbergii, Acer rubrum, Cornus florida, Ostrya virginiana, Aesculus sylvatica*, and *Ilex opaca*. Some of these forests, particularly in the Piedmont of South Carolina or in Arkansas, may have *Acer barbatum*. Shrubs in this alliance include *Vaccinium stamineum, Viburnum rafinesquianum, Euonymus americana*, and, in some occurrences, *Kalmia latifolia*. The herb layer can be relatively lush with such species as *Polystichum acrostichoides, Galium circaezans, Hexastylis arifolia, Hexastylis minor, Desmodium nudiflorum, Erythronium umbilicatum ssp. umbilicatum, Hepatica nobilis var. obtusa, Epifagus virginiana, Tiarella cordifolia var. collina, Heuchera americana, Stellaria pubera, Podophyllum peltatum, Botrychium virginianum*, and others present. These forests often occur on north-facing slopes, low slopes, high terraces along streams, and possibly other situations. Forests in this alliance occur in the Cumberlands and Southern Ridge and Valley, Piedmont and Interior Low Plateau, and on protected slopes and ravines in the Ozarks, central Ouachita Mountains, and Arkansas Valley.

***LIRIODENDRON TULIPIFERA* FOREST ALLIANCE:** This alliance includes deciduous forests dominated by *Liriodendron tulipifera*, primarily in areas which were once clearcut, old fields, or cleared by fire or other natural disturbances. These non-wetland forests are also found along mesic stream terraces and on upland mountain benches. Forests in this alliance are abundant in the central and southern Appalachians, below 3000 feet (900 m) elevation, usually associated with disturbance and on the most productive sites, but also occur in the Coastal Plain, Piedmont, Ridge and Valley, and Cumberland Plateau. This alliance includes pure, often even-aged stands of *Liriodendron tulipifera* as well as forests with *Liriodendron tulipifera* associated with other species favored by canopy openings. Associated species vary with geographic location. Throughout most of the range of this alliance, *Acer rubrum, Robinia pseudoacacia, Betula lenta, Acer saccharum*, and *Acer negundo* are common components. In the Piedmont and Coastal Plain, *Liquidambar styraciflua* is a common associate. In the Appalachians, *Halesia tetraptera, Tsuga canadensis, Tilia americana var. heterophylla (= Tilia heterophylla), Prunus serotina var. serotina*, and *Magnolia fraseri* can be additional components. In the Ridge and Valley and Cumberland Plateau, additional species include *Quercus rubra, Magnolia acuminata, Carya alba, Carya glabra, Pinus virginiana, Sassafras albidum, Pinus strobus, Carpinus caroliniana, Asimina triloba*, and *Staphylea trifolia*. Herbaceous strata are not diverse and, in the southern Appalachians, this feature distinguishes these forests from rich cove forests in I.B.2.N.a *Liriodendron tulipifera - Tilia americana var. heterophylla - Aesculus flava - Acer saccharum Forest Alliance (A.235)*. Vines can be abundant including *Vitis* spp., *Smilax* spp., *Aristolochia macrophylla*, and *Parthenocissus quinquefolia*. Forests in this alliance occur on middle to lower slopes, sheltered coves and gentle concave slopes, and river terraces over various soils and geologies. Vegetation of this alliance is uncommon in Louisiana.

***QUERCUS ALBA* - (*QUERCUS RUBRA*, *CARYA SPP*.) FOREST ALLIANCE:** This alliance is widely distributed in the eastern United States and portions of adjacent Canada and includes dry mesic to mesic upland oak forests dominated by *Quercus alba* and/or *Quercus rubra*, with or without *Carya* species. Stands are 15-25 m tall, with a closed, deciduous canopy. The shrub and herbaceous strata are typically well-developed. *Quercus alba* usually dominates the stands, either alone or in combination with *Quercus rubra* (especially on moister sites) and sometimes *Quercus velutina* (especially on drier sites). Some associations in this alliance are dominated by *Quercus rubra*, although *Quercus alba* is usually also a canopy component. *Carya* species (particularly *Carya alba, Carya glabra* or *Carya ovata*) are typically common either in the canopy or subcanopy. In the southeastern United States, this alliance covers dry-mesic forests of the Piedmont, low Appalachian Mountains, and the Cumberland and Interior Low Plateau, and mesic oak-hickory forests of the Blue Ridge and the interior highlands of the Ozarks and Ouachita Mountains. Associated species in the southeastern United States include *Carya glabra, Carya ovata, Carya alba, Fraxinus americana, Acer rubrum, Acer leucoderme, Cornus florida, Nyssa sylvatica, Ostrya virginiana, Calycanthus floridus, Pyrularia pubera, Tilia americana var. caroliniana, Oxydendrum arboreum*, and others. This alliance is found throughout the midwestern United States on moderately rich, upland sites. Typical associates include *Fraxinus americana, Ulmus americana, Tilia americana, Acer saccharum, Acer rubrum*, and more locally, *Quercus macrocarpa* and *Quercus ellipsoidalis*.
Stands are found on gentle to moderately steep slopes on uplands and on steep valley sides. The soils are moderately deep to deep and vary from silts to clays and loams. The parent material ranges from glaciated till to limestone, shale, sandstone and other bedrock types. In the midwestern United States, many stands are succeeding to types dominated by *Acer saccharum, Tilia americana, Acer rubrum*, and other mesic tree associates. This succession may be delayed by fire and grazing. In the eastern and southeastern United States, *Liriodendron tulipifera, Fraxinus americana, Acer rubrum*, and other mesic associates often increase after disturbances, such as clearcutting or windstorms, especially in the absence of fire.

***QUERCUS ALBA* - *QUERCUS* (*FALCATA, STELLATA*) FOREST ALLIANCE:** This alliance contains vegetation that can be described as dry oak and oak - hickory forests. These are usually dominated by a mixture of *Quercus alba* and *Quercus falcata*; *Quercus stellata* may be dominant or codominant. In addition, *Quercus coccinea, Quercus velutina, Quercus marilandica, Carya alba, Carya glabra, Carya pallida, Carya carolinae-septentrionalis, Carya ovata*, and *Fraxinus americana* often are present. Common subcanopy and shrub species include *Oxydendrum arboreum, Acer rubrum, Ulmus alata, Juniperus virginiana var. virginiana, Vaccinium arboreum, Cornus florida, Sassafras albidum, Gaylussacia frondosa (= var. frondosa), Gaylussacia baccata, Vaccinium pallidum*, and *Vaccinium stamineum*. Herbaceous species that may be present include *Chimaphila maculata, Polystichum acrostichoides, Asplenium platyneuron, Hexastylis arifolia, Coreopsis major, Tephrosia virginiana, Sanicula canadensis, Desmodium nudiflorum, Desmodium nuttallii, Symphyotrichum urophyllum? (= Aster sagittifolius?), Symphyotrichum patens (= Aster patens), Solidago ulmifolia*, and *Hieracium venosum*. These often are successional forests following logging and/or agricultural cropping. Some examples occur in upland flats and have been called xerohydric because they occasionally will have standing water in the winter due to a perched water table, but are droughty by the end of the growing season. Other occurrences are found on well-drained sandy loam or clay loam soils that are often, although not always, shallow. Karst topography can be found in areas where this alliance occurs. Soils are most often a well-drained sandy loam, although clay loams are not uncommon. Forests of this alliance may occupy narrow bands of dry-mesic habitat transitional between lower and midslope mesic communities and xeric ridgetops. This alliance is found in the Upper East Gulf Coastal Plain, Piedmont, low mountains (including Cumberlands and Ridge and Valley), and Interior Low Plateau. Distribution in the Atlantic Coastal Plain, East Gulf Coastal Plain, and Upper West Gulf Coastal Plain needs assessment. In the Shawnee Hills, Knobs, Coastal Plain, and Appalachian Plateau regions of Kentucky, these forests form a common matrix vegetation over acid sandstone and shales. These Kentucky forests are dominated by *Quercus alba* with little or no *Quercus falcata* and occupy middle to upper slope positions. In the southern Illinois portion of the range, examples occur on south- to west-facing slopes where increased temperatures favor *Quercus falcata* over *Quercus rubra*.

***QUERCUS PRINUS* - *QUERCUS (ALBA, FALCATA, RUBRA, VELUTINA)* FOREST ALLIANCE:** Dry-mesic to mesic forests dominated by *Quercus prinus* occurring in admixture with other *Quercus* species, in the Blue Ridge, Piedmont, Ridge and Valley, Cumberland Plateau, and the Interior Low Plateau. *Quercus prinus* is the leading dominant in these forests, but other common canopy species can include *Quercus alba, Quercus coccinea, Quercus falcata, Quercus rubra, Quercus velutina, Acer rubrum, Carya alba, Carya glabra, Carya ovalis, Carya* *ovata, Carya pallida, Fagus grandifolia, Liriodendron tulipifera, Nyssa sylvatica*, and *Pinus strobus*. The subcanopy often contains *Cornus florida* and *Oxydendrum arboreum*. Drier examples can contain *Juniperus virginiana var. virginiana*. Other common species in the subcanopy/shrub stratum include *Acer rubrum, Carya glabra, Cercis canadensis, Hamamelis virginiana, Kalmia latifolia, Nyssa sylvatica, Rhododendron calendulaceum, Rhododendron maximum, Robinia pseudoacacia, Stewartia ovata, Symplocos tinctoria, Vaccinium stamineum*, and *Viburnum acerifolium*. The ground flora varies depending on available light, moisture, and soil nutrients but can be quite diverse, especially in associations with sparse shrub cover. Herbaceous species characteristic of these dry-mesic to mesic oak - hickory forests include *Symphyotrichum cordifolium (= Aster cordifolius), Symphyotrichum retroflexum (= Aster curtisii), Eurybia macrophylla (= Aster macrophyllus), Symphyotrichum undulatum (= Aster undulatus), Botrychium virginianum, Carex nigromarginata, Chimaphila maculata, Actaea racemosa (= Cimicifuga racemosa), Collinsonia canadensis, Coreopsis major, Cypripedium parviflorum var. pubescens (= Cypripedium pubescens), Danthonia compressa, Danthonia spicata, Dioscorea villosa, Epigaea repens, Eupatorium album, Eupatorium purpureum, Galax urceolata, Galium triflorum, Houstonia purpurea (= Hedyotis purpurea), Hieracium venosum, Iris cristata, Maianthemum racemosum, Medeola virginiana, Melanthium parviflorum, Polystichum acrostichoides, Prenanthes altissima, Pycnanthemum incanum, Scutellaria ovata, Tephrosia virginiana, Uvularia perfoliata*, and *Uvularia puberula*. Vines are common and species that may be present include *Parthenocissus quinquefolia, Smilax* spp., and *Toxicodendron radicans*. In the Cumberland Plateau, forests in this alliance have replaced forests once dominated by *Castanea dentata* and often have chestnut sprouts in the understory. Forests in this alliance are known from moderately sheltered low ridges, flats, and valleys at lower elevations (762-1036 m; 2500-3400 feet) in the Blue Ridge and from upper slopes, draws, and gorge slopes in the Cumberland Plateau, and from upper to middle, dry-mesic slopes in the Piedmont. This alliance provisionally includes forests over limestone in the lower portions of the Ridge and Valley.

I.B.2.N.d TEMPORARILY FLOODED COLD-DECIDUOUS FOREST

***FAGUS GRANDIFOLIA* TEMPORARILY FLOODED FOREST ALLIANCE:** This alliance contains vegetation that occurs along small streams and is dominated by *Fagus grandifolia*. Other canopy species include *Quercus alba, Quercus rubra var. rubra, Quercus laurifolia, Acer barbatum, Quercus shumardii var. shumardii, Liquidambar styraciflua, Magnolia grandiflora* (within its range), *Quercus michauxii, Fraxinus pennsylvanica*, and *Acer rubrum var. rubrum*. The subcanopy and shrub layers often contain *Asimina triloba, Ilex opaca var. opaca, Cornus florida, Cornus foemina, Magnolia acuminata, Carpinus caroliniana ssp. caroliniana, Hamamelis virginiana, Ostrya virginiana var. virginiana, Oxydendrum arboreum, Alnus serrulata, Calycanthus floridus var. floridus, Rhododendron arborescens*, and *Vaccinium elliottii*; and fairly dense coverage by *Cyrilla racemiflora* over *Kalmia latifolia* is present in an occurrence in the Piedmont of North Carolina. Herbaceous species common to forests in this alliance include *Carex glaucescens, Carex intumescens, Chasmanthium latifolium, Anemone quinquefolia var. quinquefolia, Anemone virginiana var. virginiana, Carex blanda, Carex laxiflora var. laxiflora, Carex striatula, Chamaelirium luteum, Chrysogonum virginianum, Dioscorea quaternata, Dichanthelium* spp., *Gelsemium sempervirens, Polystichum acrostichoides var. acrostichoides, Heuchera americana, Mitchella repens, Hexastylis minor, Hexastylis arifolia var. arifolia*, and *Xanthorhiza simplicissima* among others. The distribution of this alliance is incomplete, but it is known from at least the Piedmont of North Carolina, Virginia, and South Carolina, the West Gulf Coastal Plain, southern Indiana, Pennsylvania, and possibly southern Ontario in Canada.

***PLATANUS OCCIDENTALIS* - (*LIQUIDAMBAR STYRACIFLUA, LIRIODENDRON TULIPIFERA*) TEMPORARILY FLOODED FOREST ALLIANCE:** Forests in this alliance typically are dominated by *Platanus occidentalis* with *Liquidambar styraciflua* and/or *Liriodendron tulipifera*, and typically occur on rocky streambeds and alluvial deposits on relatively high-gradient rivers. The alliance is distributed in the upper Piedmont, Appalachian Mountains, Interior Low Plateau, Cumberland Mountains, and Cumberland Plateau regions. In the eastern part of the Interior Low Plateau, vegetation of this alliance may be in lower gradient situations. Other canopy and understory species that may be present include *Aesculus sylvatica* (within its range), *Asimina triloba, Cornus florida, Alnus serrulata, Fraxinus americana, Acer rubrum, Carpinus caroliniana, Ulmus americana*, and *Fagus grandifolia* in the non-montane part of the distribution. Species present in the montane occurrences include *Platanus occidentalis, Liriodendron tulipifera, Betula alleghaniensis*, and *Betula lenta*, with *Carpinus caroliniana, Hamamelis virginiana, Liquidambar styraciflua, Betula nigra, Fraxinus americana, Acer rubrum, Pinus virginiana,* *Pinus strobus*, and *Tsuga canadensis*. *Euonymus americana* is a typical shrub species in the lower elevation occurrences, while *Rhododendron maximum* and *Leucothoe fontanesiana* are common at higher elevations. Herbaceous species vary as well by geography and elevation, and may include *Arisaema triphyllum, Sanicula canadensis, Saururus cernuus, Campanula divaricata, Dichanthelium dichotomum var. dichotomum, Amphicarpaea bracteata, Actaea racemosa (= Cimicifuga racemosa), Polystichum acrostichoides, Eurybia divaricata (= Aster divaricatus), Viola sororia*, and *Viola blanda*. *Carex* species may be common (e.g., *Carex appalachica, Carex austrocaroliniana, Carex blanda, Carex crinita, Carex digitalis, Carex plantaginea, Carex swanii*, and/or *Carex torta*).

***SALIX NIGRA* TEMPORARILY FLOODED FOREST ALLIANCE:** This alliance contains vegetation that is dominated by *Salix nigra* and that occurs in temporarily flooded sites, i.e., surface water is present for brief periods during the growing season, but the water table usually lies well below soil surface. Other canopy species that may be present include *Populus deltoides, Planera aquatica, Betula nigra, Platanus occidentalis, Celtis laevigata, Fraxinus pennsylvanica, Carya illinoinensis, Diospyros virginiana, Quercus nigra, Cornus drummondii, Ulmus americana, Acer rubrum, Acer negundo, Acer saccharinum* (in the Mississippi River Alluvial Plain north of Memphis, Tennessee), and *Morus rubra*. The herbaceous and shrub strata may be absent to fairly dense, and species that may be present include *Ampelopsis arborea, Mikania scandens, Toxicodendron radicans, Polygonum* spp., *Erechtites hieraciifolia, Boehmeria cylindrica, Commelina virginica, Phytolacca americana, Asplenium platyneuron*, and others. This alliance is common on the fronts of both small rivers and streams and larger rivers where it is a component of point bar succession. This alliance is common throughout the southeastern and southern midwestern United States.

I.C.3.N.a MIXED NEEDLE-LEAVED EVERGREEN – COLD-DECIDUOUS FOREST

***PINUS ECHINATA - QUERCUS* (*ALBA, FALCATA, STELLATA, VELUTINA*) FOREST ALLIANCE:** This alliance occurs in the southeastern United States from the inner coastal Plain and Piedmont, ranging north and west through the Cumberland Plateau, Ridge and Valley, and low Blue Ridge, and from eastern Texas and Louisiana, through the Ouachita Mountains and Ozarks. It includes dry-mesic forests with mixed evergreen and deciduous canopies where *Pinus echinata* and one or more of the nominal *Quercus* spp. occur in varying ratios. In some associations *Pinus taeda* may be a dominant evergreen canopy component. *Quercus rubra* codominates in associations in the Ozarks and Ouachita Mountains. Other common species vary greatly with geography, but can include *Carya alba, Carya texana, Sassafras albidum, Oxydendrum arboreum, Acer rubrum, Nyssa sylvatica, Cornus florida, Vaccinium arboreum, Vaccinium pallidum, Vaccinium stamineum, Chimaphila maculata, Tephrosia virginiana, Coreopsis major*, and others. Forests in this alliance occur primarily on dry hilltops, upper slopes, and ridges on acidic soils.

***PINUS VIRGINIANA - QUERCUS* (*ALBA, STELLATA, FALCATA, VELUTINA*) FOREST ALLIANCE:** This alliance includes forests with mixed evergreen/deciduous canopies composed primarily of *Pinus virginiana*, with various admixtures of the nominal *Quercus* spp. (*Quercus alba, Quercus stellata, Quercus falcata, Quercus velutina*).

II.A.4.N.a ROUNDED-CROWNED TEMPERATE OR SUBPOLAR NEEDLE-LEAVED EVERGREEN WOODLAND

***PINUS* (*VIRGINIANA*) *- QUERCUS PRINUS* WOODLAND ALLIANCE**: This alliance includes woodland vegetation dominated by *Pinus virginiana*. Associations in this alliance are possible from central Pennsylvania southwest to northeastern Alabama, but tend to occur under extreme conditions (such as steep, shaley slopes) that maintain the open structure of the vegetation.

II.A.4.N.b CONICAL-CROWNED TEMPERATE OR SUBPOLAR NEEDLE-LEAVED EVERGREEN WOODLAND

***JUNIPERUS VIRGINIANA* WOODLAND ALLIANCE:** This alliance, found in the central, eastern, and southeastern United States, contains rocky woodlands dominated by *Juniperus virginiana*. Associated woody species include *Quercus muehlenbergii, Quercus stellata*, and *Fraxinus quadrangulata* on calcareous or circumneutral sites; and *Liquidambar styraciflua* and others on old fields. Some examples occur as shale woodlands in the Ouachita Mountains, rimrock glades and cliffs, and as fire-suppressed glades and prairies. In Louisiana, this community is found on calcareous clays of the Jackson Formation. This alliance occurs in the Piedmont, Interior Low Plateau, West Gulf Coastal Plain, Ozark Plateau, Ouachita Mountains, and Arkansas Valley. More information is needed on the range of variability and the exact distribution of this alliance.
Note that *Juniperus virginiana var. virginiana*-dominated communities occurring in old pastures, cleared calcareous areas, and so forth are placed in the I.A.8.N.c *Juniperus virginiana Forest Alliance (A.137)*, whether the canopy is closed or open.

II.B.2.N.a COLD-DECIDUOUS WOODLAND

***QUERCUS ALBA - QUERCUS STELLATA - QUERCUS VELUTINA* - (*QUERCUS FALCATA*) WOODLAND ALLIANCE:** This alliance contains a variety of bedrock-influenced, fire-dependent, dry-mesic woodlands with shallow soils. Abundant trees are *Quercus alba, Quercus falcata, Quercus marilandica, Quercus stellata, Quercus velutina, Crataegus* spp., and *Pinus echinata*. In western Arkansas, *Quercus rubra* may be a canopy dominant. Taller shrubs include *Crataegus* spp., *Rhus aromatica, Vaccinium arboreum*, and *Vaccinium pallidum*. *Schizachyrium scoparium* is a common herbaceous species. Others that may be present include *Andropogon gerardii, Helianthus microcephalus, Polygonella americana, Sorghastrum nutans*, and *Solidago odora*. Lichens and mosses are often found in drier stands of this alliance. Stands of this alliance are found on gentle to steep hills, plains, and ridges. Soils are well- to very rapidly drained and very shallow to deep (10-100 cm). Parent material is sand, chert, sandstone, or, rarely, igneous rock with areas of rock or residuum present at the surface.

II.B.2.N.b TEMPORARILY FLOODED COLD-DECIDUOUS WOODLAND

***PLATANUS OCCIDENTALIS* - (*BETULA NIGRA, SALIX SPP.*) TEMPORARILY FLOODED WOODLAND ALLIANCE:** These woodlands occur on wet flats and high-energy river shores; they are naturally or artificially disturbed and therefore maintain an open canopy. They are typically dominated by some combination of *Platanus occidentalis, Betula nigra, Salix nigra*, and *Salix caroliniana*. In addition to the nominal species, the canopy may include *Acer negundo* and *Acer rubrum*. The physiognomic expression of this vegetation is highly variable; some examples have a substantial shrubby component. Texas examples (e.g., in the Edwards Plateau) contain *Platanus occidentalis* and few other trees; *Salix nigra, Juglans microcarpa*, and/or *Juglans major* may be present, also *Acer grandidentatum* and *Prunus serotina var. eximia*.

II.C.3.N.a MIXED NEEDLE-LEAVED EVERGREEN – COLD-DECIDUOUS WOODLAND

***PINUS ECHINATA - QUERCUS* (*ALBA, FALCATA, STELLATA, VELUTINA*) WOODLAND ALLIANCE:** Woodlands in this alliance are found on edaphically extreme sites, generally with a southern aspect. This alliance includes fire-maintained shortleaf pine - oak woodlands found in northwestern Arkansas, as well as in the middle coastal plain. "Shield barrens" of sandstone areas in southwestern Virginia are also a component of this alliance. Natural as well as managed types are included here, in particular intensively managed shortleaf pine, maintained by winter burning, with a dense 2 m tall layer of saplings, thinned to woodland density, of Texas and possibly other states. The natural woodland condition is uncommon for vegetation dominated by shortleaf pine and oaks from the Ouachita Mountains of Arkansas. Some occurrences are known from Kentucky and other states east of the Mississippi, but their taxonomic status is unclear.

III.A.2.N.a TEMPERATE BROAD-LEAVED EVERGREEN SHRUBLAND

LIGUSTRUM SINENSE **UPLAND SHRUBLAND:** This alliance consists of upland areas, mostly moist, dominated by the exotic *Ligustrum sinense*, with little or no canopy. Density of the shrub layer may be such that there is no development of the herbaceous stratum. *Ligustrum sinense* is a serious weedy species in the southeastern United States; generally it occurs as a shrub-layer dominant under tree canopies, especially in floodplains; such sites are considered degraded occurrences of the equivalent natural forest community.

III.B.2.N.a TEMPERATE COLD-DECIDUOUS SHRUBLAND

RUBUS **(*ARGUTUS, TRIVIALIS*) SHRUBLAND ALLIANCE:** Successional vegetation following disturbance (complete forest canopy removal) dominated by *Rubus argutus* and/or *Rubus trivialis*. Many examples also contain *Smilax spp*. And a great variety of tree saplings and other woody species. In central Tennessee, these may include *Quercus spp*., *Liquidambar styraciflua*, *Acer rubrum*, and *Rhus copallinum*. Herbs in central Tennessee may include *Solidago spp*., *Aster spp*., *Helianthus spp*., *Hypericum spp*., *Potentilla simplex*; grasses may include *Andropogon spp*., *Dichanthelium spp*., *Panicum spp*., *Schizachyrium scoparium*, and *Sorghastrum nutans*.

III.B.2.N.d TEMPORARILY FLOODED COLD-DECIDUOUS SHRUBLAND

ALNUS SERRULATA **TEMPORARILY FLOODED SHRUBLAND ALLIANCE**: Stands of this temporarily flooded shrubland are dominated by *Alnus serrulata*. It occurs in the Interior Low Plateau, Piedmont, and Crosstimbers, and is possible in the upper West and East Gulf coastal plains. States of occurrence likely include Arkansas, Georgia, Louisiana, Oklahoma, Tennessee, and Kentucky. More information is needed to adequately describe and evaluate the distribution and rank of this association. It may require subdivision as more information becomes available.

III.C.2.N.a MIXED EVERGREEN-COLD-DECIDUOUS SHRUBLAND

V.A.5.C.x PLANTED OR CULTIVATED TEMPERATE OR SUBPOLAR GRASSLAND

APPENDIX G. Anderson Level I and II Classes Identified at Appomattox Court House National Historical Park

Urban or build-up land

- Residential
- Industrial
- Transportation

Agricultural land

- Cropland and pasture

Water

Barren land

- Transitional areas

APPENDIX H. Sampling Script Written For Use With USGS-NPS Vegetation Mapping Accuracy Assessment by Frank Koch

```
/3.2
(Extension.1
	Name: "USGS-NPS Sampling Tools"
	FirstRootClassName:	"PMenu"
	Roots:	2
	Roots:	6
	Roots:	8
	Roots:	10
	Roots:	12
	Roots:	13
	Roots:	14
	Version:	32
	About:	"Contains a set of tools for generating sample points
according to the USGS-NPS Vegetation Mapping Program protocol."
	InstallScript:	15
	UninstallScript:	16
	ExtVersion: 1
)

(PMenu.2
	InternalName:	"USGS-NPS Tools"
	Help: "\n"
	Child:	3
	Child:	4
	Child:	5
	Label:	"&USGS-NPS"
)

(Choice.3
	Help: "Creates a table listing the number of sample points required for
each vegetation class, according to USGS-NPS Vegetation Mapping Program
protocol."
	Label:	"&Create Summary Table..."
	Click:	"USGS_NPS.SampleSummaryTable"
	Shortcut:	"Keys.None"
)

(Choice.4
	Help: "Creates a stratified random sample of the vegetation polygons
based on a USGS-NPS summary table.  The returned point theme is derived from
the polygon centroids."
	Label:	"&Stratified Random Sample..."
	Click:	"USGS_NPS.StratifRandomSampler"
	Shortcut:	"Keys.None"
)

(Choice.5
	Help: "Adds X and Y coordinates to a theme of sample points."
	Tag:  "XY"
	Label:	"&Add XY Coordinates..."
	Click:	"USGS_NPS.SamplePtsAddXY"
```

```
      Shortcut:   "Keys.None"
)

(Butn.6
      InternalName:     "Sample Summary Table"
      Help: "Create Summary Table//Creates a table listing the number of
sample points required for each vegetation class, according to USGS-NPS
Vegetation Mapping Program protocol."
      Icon: 7
      Click:      "USGS_NPS.SampleSummaryTable"
)

(AVIcon.7
      Name: "Summarize2"
      Res:  "Icons.Summarize2"

)

(Butn.8
      InternalName:     "Stratified Random Sampler"
      Help: "Stratified Random Sample//Creates a stratified random sample of
the vegetation polygons based on a USGS-NPS summary table.  The returned
point theme is derived from the polygon centroids."
      Icon: 9
      Click:      "USGS_NPS.StratifRandomSampler"
)

(AVIcon.9
      Name: "BoxLargeDot"
      Res:  "Icons.BoxLargeDot"

)

(Butn.10
      InternalName:     "Add XY Coordinates"
      Help: "Add XY Coordinates//Adds X and Y coordinates to a theme of
sample points."
      Icon: 11
      Click:      "USGS_NPS.SamplePtsAddXY"
)

(AVIcon.11
      Name: "XY"
      Res:  "Icons.XY"

)

(Script.12
      Name: "USGS_NPS.SamplePtsAddXY"
      SourceCode: "'This script is part of the USGS_NPS sampling tools
extension\n'Frank Koch 5/04/01\n\n'Make sure map units set to meters\ntheView
= av.GetActiveDoc\ntheView.SetUnits(#UNITS_LINEAR_METERS)\n\n'Check if point
file was created using the USGS-NPS extension\ntheAnswer = MsgBox.YesNo(\"Was
the sample point file created with the other USGS-NPS tools?\",\"Point File
Origin\",TRUE)\nIf (theAnswer = False) Then\n  MsgBox.Warning(\"Try the
```

```
ArcView sample script for adding X and Y coordinates instead.\",\"Sorry!\")\n
Return Nil\nEnd\n\n'Ch
eck if theme is point\ntheThemeList = theView.GetThemes\ntheTheme =
MsgBox.Choice(theThemeList, \"Please select the sample point theme:\",
\"Select Point Theme\")\nIf (theTheme = Nil) Then\n  Return Nil\nElseif
((theTheme.GetSrcName.GetSubName = \"point\").Not) Then\n
MsgBox.Warning(\"Theme must be point.\",\"Point Theme Only!\")\n  Return
Nil\nEnd\n\n'Find fields and edit state of the theme table\ntheFTab =
theTheme.GetFTab\ntheFields = theFTab.GetFields\nedit_state =
theFTab.IsEditable\n\n'Make sure table is editable and that fi
elds can be added\nif (theFtab.CanEdit) then\n  theFTab.SetEditable(true)\n
if ((theFTab.CanAddFields).Not) then\n    MsgBox.Info(\"Can't add fields to
the table.\"+NL+\"Check write permission.\",\n    \"Can't add X,Y
coordinates\")\n    exit\n  end\nelse\n  MsgBox.Info(\"Can't modify the
feature table.\"+NL+\n  \"Check write permission.\",\"Can't add X,Y
coordinates\")\n  exit\nend\n\n'Check if fields named \"X-coord\" and \"Y-
coord\" exist\nx_exists = (theFTab.FindField(\"X-coord\") =
NIL).Not\ny_exists = (theFtab.FindField(\"Y-coord\") =
NIL).Not\n\n'Overwrite previous \"X-coord\" and \"Y-coord\" if user
wishes\nif (x_exists or y_exists) then \n  if (MsgBox.YesNo(\"Overwrite
existing fields?\",\n  \"X-coord, Y-coord fields already exist\", false))
then\n    'if ok to overwrite, delete the fields as they may not be defined\n
'as required by this script (eg., created from another script).\n    if
(x_exists) then\n      theFTab.RemoveFields({theFTab.FindField(\"X-
coord\")})\n    end\n    if (y_exists) then\n
theFTab.RemoveFields({theFTab.FindField(\"Y-coord\"
)})\n    end\n  else\n    exit\n  end  'if (MsgBox...)\nend  'if\n\n'Make new
\"X-coord\" and \"Y-coord\" fields\nx = Field.Make (\"X-
coord\",#FIELD_DECIMAL,18,5)\ny = Field.Make (\"Y-
coord\",#FIELD_DECIMAL,18,5)\ntheFTab.AddFields({x,y})\n\ntheFTab.Calculate(\
"[Shape].GetX\", x)\ntheFTab.Calculate(\"[Shape].GetY\", y)\n\n'Return
editing state to pre-script running state\ntheFTab.SetEditable(edit_state)\n"
)

(Script.13
      Name: "USGS_NPS.SampleSummaryTable"
      SourceCode: "'This script is part of the USGS_NPS sampling tools
extension\n'Frank Koch 5/04/01\n\n'Make sure data is projected and in
meters\ntheView = av.GetActiveDoc\ntheChoice = MsgBox.YesNo(\"The data are
assumed to be projected and the map units in meters. Is this true?\", \"Units
must be meters!\", TRUE)\nIf (theChoice = False) Then\n
MsgBox.Warning(\"Please project the data as necessary before using this
application.\",\"Project and Retry\")\n  Return Nil\nElse \n
theView.SetUnits(#UNITS_LINEAR_METERS)\nEnd\n\n'User selects the ve
getation theme for summary of classes   \ntheThemeList =
theView.GetThemes\ntheTheme = MsgBox.Choice(theThemeList,\"Please select the
vegetation theme:\", \"Select Theme For Sampling\")\nIf (theTheme = nil)
Then\n  Return Nil\nEnd\n\n'Deactivate all themes except the vegetation
theme\nFor Each thm in theThemeList\n  If (thm.IsActive = true) Then\n
thm.SetActive(false)\n  End\nEnd\ntheTheme.SetActive(true)\n\n'Check if theme
is polygon\ntheFTab = theTheme.GetFTab\ntheThemeShape =
theFTab.GetShapeClass.GetClassName\nIf (theThem
eShape = \"Polygon\") Then\n  theSelBitMap = theFTab.GetSelection\n
theSelBitMap.ClearAll\nElse\n  Msgbox.Warning(\"Vegetation must be a polygon
theme.\",\"Polygon Theme Only!\")\n  Return Nil\nEnd\n\n'Make sure table is
```

```
editable and that fields can be added\ntheFTabFields =
theFTab.GetFields\nedit_state = theFTab.IsEditable\n\nif (theFtab.CanEdit)
then\n  'Start editing\n  theFTab.SetEditable(True)\n  if
((theFTab.CanAddFields).Not) then\n    MsgBox.Info(\"Can't add fields to the
table.\"+NL+\"Check write permission.\",\n    \"Can't
 add summary data\")\n    Return Nil\n  end\nelse\n  MsgBox.Info(\"Can't
modify the feature table.\"+NL+\n  \"Check write permission.\",\"Can't add
summary data\")\n  Return Nil\nend\n\nMsgBox.Info(\"A field listing the area
of each polygon in hectares will now be added to the table.\",\"New Area
Field\")\n\n'Following code creates or overwrites hectares field, adds area
for each polygon\nhectares_exists = (theFTab.FindField(\"Hectares\") =
Nil).Not\n\nIf (hectares_exists) then \n  If (MsgBox.YesNo(\"Overwrite
existing fields?\",\"Hectar
es field already exists\", false)) Then\n      'Delete existing hectares
field\n      theFTab.RemoveFields({theFTab.FindField(\"Hectares\")})\n  End
\nEnd  \n\n'Create new hectares field\nareaField =
Field.Make(\"Hectares\",#FIELD_DECIMAL, 15,
2)\ntheFTab.AddFields({areaField})\ntheFTab.Calculate(\"[Shape].ReturnArea/10
000\",areaField)\n'Stop editing\ntheFTab.SetEditable(False)\n\n'Select the
field that has the vegetation codes or categories\ntheFieldList =
theTheme.GetFTab.GetFields\ntheClassifField = MsgBox.Choice(theFieldList
, \"Please select the classification field:\", \"Select Field For
Sampling\")\nIf (theClassifField = Nil) Then\n  Msgbox.Warning(\"You have
just bailed out of the application!\",\"Application Terminated\")\n  Return
Nil\nEnd\n\n'Create a file for saving summary table\ndef =
av.GetProject.MakeFileName(\"Class\", \"dbf\")\ndef = FileDialog.Put(def,
\"*.dbf\", \"Save the sampling summary table:\")\nIf (def = Nil) Then\n
Return Nil\nEnd\n\n'Summarize the vegetation theme\nnewVTab =
theFTab.Summarize(def, dBase, theClassifField, {areaField}
, {#VTAB_SUMMARY_SUM})\n\n'Find criteria fields(# of polygons, polygon area)
for USGS-NPS accuracy assessment protocol\ntheCount =
newVTab.FindField(\"Count\")\ntheArea =
newVTab.FindField(\"Sum_hectar\")\ntheCategory =
newVTab.FindField(theClassifField.AsString)\n\n'Make a new sample points
field\nnewVTab.SetEditable(True)\nSampleField =
Field.Make(\"Sample_pts\",#FIELD_DECIMAL, 15,
0)\nnewVTab.AddFields({SampleField})\n\n'Finds number of sample points
required for each vegetation category\n'Based on USGS-NPS Vegetation Mapp
ing Program criteria\nFor each record in newVTab\n  theC =
newVTab.ReturnValue(theCount, record)\n  theA = newVTab.ReturnValue(theArea,
record)\n  theCat = newVTab.ReturnValue(theCategory, record) \n  If ((theC >=
30) and (theA > 50)) Then\n    theSampleSize = 30\n  Elseif ((theC >= 20) and
(theC < 30) and (theA > 50)) Then\n    theSampleSize = 20\n  Elseif ((theC >
30) and (theA < 50)) Then\n    theSampleSize = 20\n  Elseif ((theC > 5) and
(theA < 50)) Then\n    theSampleSize = 5\n  Else \n    theSampleSize = theC\n
End
\nnewVTab.SetValue(SampleField,record,theSampleSize)\nEnd\nnewVTab.SetEditabl
e(False)\n\nTableName = MsgBox.Input(\"The summary table will now be added to
the project. Please select a display name:\",\"Name the Table\",\"Class
Summary\")\n\n'Make the summary table window and add it to the
project\nClassTable =
Table.Make(newVTab)\nClassTable.SetName(TableName)\nav.GetProject.AddDoc(Clas
sTable)\nClassTable.GetWin.Open"
)
```

```
(Script.14
      Name: "USGS_NPS.StratifRandomSampler"
      SourceCode: "'This script is part of the USGS_NPS sampling tools
extension\n'Frank Koch 5/04/01\n\n'Make sure map units set to meters\ntheView
= av.GetActiveDoc\ntheView.SetUnits(#UNITS_LINEAR_METERS)\n\n'User selects
the vegetation theme \ntheThemeList = theView.GetThemes\ntheTheme =
MsgBox.Choice(theThemeList, \"Please select the vegetation theme:\", \"Select
Theme For Sampling\")\nIf (theTheme = Nil) Then\n  Return Nil\nEnd\n\n'Check
if vegetation theme is polygon\ntheFTab = theTheme.GetFTab\ntheThemeShape =
theFTab.GetShapeClass.GetCla
ssName \nIf (theThemeShape = \"Polygon\") Then\n  theBitMap =
theFTab.GetSelection\n  theBitMap.ClearAll\nElse\n
Msgbox.Warning(\"Vegetation must be a polygon theme.\",\"Polygon Theme
Only!\")\n  Return Nil\nEnd\n\n'User selects the summary table\nTheDocList =
av.GetProject.GetDocs\ntheTable = MsgBox.Choice(TheDocList, \"Please select
the summary table:\", \"Select Class Table\")\nIf (theTable = Nil) Then\n
Return Nil\nEnd\n\ntheVTab = theTable.getVTab\ntheFieldList =
theVTab.GetFields\n'Determine the number of records and which fie
lds list the vegetation category and the number of sample points\ntheCatFld =
theFieldList.Get(0)\nthePtsFld =
theVTab.FindField(\"Sample_pts\")\nNumberOfRows =
theVTab.GetNumRecords\n\n'Pick a file name for the sample point
shapefile\ndef = av.GetProject.MakeFileName(\"Sample\", \"shp\")\ndef =
FileDialog.Put(def, \"*.shp\", \"Designate a shapefile for storing the sample
points:\")\nIf (def = Nil) Then\n  Return Nil\nEnd\n'Create FTab for point
file\nPointFTab = FTab.MakeNew(def, Point)\n'Create an ID field\nidFld =
Field.Make(\"I
D\", #FIELD_DECIMAL, 8, 0)\nPointFTab.AddFields({idFld})\nShapeField2 =
PointFTab.FindField(\"Shape\")\n\n'Based on each row in the summary table,
select a subset of the vegetation theme's records \nFor Each row in
0..(NumberOfRows-1)\n\ntheC = theVTab.ReturnValue(theCatFld, row)\ntheP =
theVTab.ReturnValue(thePtsFld, row)\n\nexpr = \"([\" + TheCatFld.AsString +
\"] = \"\"\" + theC.AsString + \"\"\")\"\n'Select the
subset\ntheFTab.Query(expr, theBitMap,
#VTAB_SELTYPE_NEW)\ntheFTab.UpdateSelection\n'Export the subset to a
temporary sh
apefile\ntemp2 = theFTab.Export(\"temp2\".AsFileName, Shape,
true)\ntheNewTheme = FTheme.Make(temp2)\n'Create a bitmap for the new
theme\ntheNewBitMap = temp2.GetSelection\nTotalRecs =
temp2.GetNumRecords\n'Up to the number of required sample points, turn on
bits in the bitmap randomly\nsetbits = 0\n while (setbits < theP )\n
newnumber = Number.MakeRandom ( 0,  TotalRecs-1)\n
theNewBitMap.Set(newnumber)\n  setbits = theNewBitmap.Count\n
end\ntheShapeField = temp2.FindField(\"Shape\")\n\n'If the bit for a
particular polygon
is turned on, find centroid of that\nFor each rec in 0..(TotalRecs-1)\n  If
(theNewBitMap.Get(rec) = TRUE) Then\n    thePolygon =
temp2.ReturnValue(theShapeField, rec)\n    thePoint =
thePolygon.ReturnCenter\n    'Add point to the point shapefile\n
NewRecordNum = PointFtab.AddRecord\n    PointFTab.SetValue(ShapeField2,
NewRecordNum, thePoint)\n  End \nEnd \n\nEnd\n\nthePointCount =
PointFTab.GetNumRecords\n\ntheList = List.Make\n\nFor Each i in
1..thePointCount\n  theList.Add(i)\nEnd \n\n'Add ID numbers for each point in
the
```

```
 point shapefile\nFor Each record in 1..thePointCount\n  curcount =
theList.Count\n  randnumber = Number.MakeRandom(0, curcount - 1)\n  IDnumber
= theList.Get(randnumber)\n  PointFTab.SetValue(idFld, record-1, IDNumber)\n
theList.Remove(randnumber)\nEnd\n  \ntheBitMap.ClearAll\n'Add point theme to
the view and turn it on\nPointFTheme =
Ftheme.Make(PointFTab)\ntheView.AddTheme(PointFTheme)\nPointFTheme.SetVisible
(TRUE)\n\nMsgBox.Info(\"Please check the position of the centroid points
before calculating X and Y coordinates.
\",\"Check The Points\")"
)

(Script.15
      Name: "Install"
      SourceCode: "'check if there's an active project\nIf (av.GetProject =
Nil) Then\n  Return Nil\nEnd\n\n'the SELF object for this script is the
extension\n'the first object added to the extension is the USGS-NPS
menu\n'the second object added  is the first new button\n'the third object
added is the second new button\n'the fourth object added is the third new
button\n\n'add the menu after all of the view's other menus\ntheMBar =
av.GetProject.FindGUI(\"View\").GetMenuBar\ntheMBar.Add(SELF.Get(0),
999)\n\n'add the button at the end of the v
iew's button bar\ntheButtonBar =
av.GetProject.FindGUI(\"View\").GetButtonBar\ntheButtonBar.Add(SELF.Get(1),
997)\n\n'add the button at the end of the view's button
bar\ntheButtonBar.Add(SELF.Get(2), 998)\n\n'add the button at the end of the
view's button bar\ntheButtonBar.Add(SELF.Get(3), 999)\n\n\n\n"
)

(Script.16
      Name: "Uninstall"
      SourceCode: "'check if there's an active project\nIf (av.GetProject =
Nil) Then\n  Return Nil\nEnd\n\n'get the menu bar in the current
project\ntheMenuBar = av.GetProject.FindGUI(\"View\").GetMenuBar\n\n'get the
button bar in the current project\ntheButtonBar =
av.GetProject.FindGUI(\"View\").GetButtonBar\n\n'remove the objects added by
the Install
script\ntheMenuBar.Remove(SELF.Get(0))\ntheButtonBar.Remove(SELF.Get(1))\nthe
ButtonBar.Remove(SELF.Get(2))\ntheButtonBar.Remove(SELF.Get(3))"
)
```

APPENDIX I. Thematic Accuracy Assessment Sampling Scheme

Excerpted from the USGS-NPS Vegetation Mapping Program Accuracy Assessment Procedures (Bailey *et al*., 1994):

It is recommended that 30 samples be specified as the maximum sample size for abundant classes, and that 5 samples be specified as the sample size for the rarest classes. Any class too rare for 5 sample sites to be selected should be observed in its entirety. Since a number of classes are intermediate in abundance between abundant and rare, five scenarios are based on class abundance and frequency have been defined:

Scenario A: The class is abundant. It covers more than 50 hectares of the total area and consists of at least 30 polygons. In this case, the recommended sample size is 30.

Scenario B: The class is relatively abundant. It covers more than 50 hectares of the total area but consists of fewer than 30 polygons. In this case, the recommended sample size is 20. The rationale for reducing the sample size for this type of class is that sample sites are more difficult to find because of the lower frequency of the class.

Scenario C: The class is relatively rare. It covers less than 50 hectares of the total area but consists of more than 30 polygons. In this case, the recommended sample size is 20. The rationale for reducing the sample size is that the class occupies a small area. At the same time, however, the class consists of a considerable number of distinct polygons that are possibly widely distributed. The number of samples therefore remains relatively high because of the high frequency of the class.

Scenario D: The class is rare. It has more than 5 but fewer than 30 polygons and covers less than 50 hectares of the area. In this case, the recommended number of samples is 5. The rationale for reducing the sample size is that the class consists of small polygons and the frequency of the polygons is low. Specifying more than 5 sample sites will therefore probably result in multiple sample sites within the same (small) polygon. Collecting 5 sample sites will allow an accuracy estimate to be computed, although it will not be very precise.

Scenario E: The class is very rare. It has fewer than 5 polygons and occupies less than 50 hectares of the total area. In this case, it is recommended that the existence of the class be confirmed by a visit to each sample site. The rationale for the recommendation is that with fewer than 5 sample sites (assuming 1 site per polygon), no estimate of level of confidence can be established for the sample (the existence of the class can only be confirmed through field checking).

APPENDIX J. Camera Calibration Report

United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Reston, Virginia 20192

REPORT OF CALIBRATION
of Aerial Mapping Camera

August 3, 2000

Camera type: Wild RC20*
Lens type: Wild Universal Aviogon A4-F
Nominal focal length: 153 mm

Camera serial no.: 5062
Lens serial no.: 13110
Maximum aperture: f/4
Test aperture: f/4

Submitted by: Air Photographics, Inc.
Martinsburg, West Virginia

Reference: Air Photographics, Inc. purchase
order No. 2427, dated August 2, 2000.

These measurements were made on Kodak Micro-flat glass plates, 0.25 inch thick, with spectroscopic emulsion type 157-01 Panchromatic, developed in D-19 at 68° F for 3 minutes with continuous agitation. These photographic plates were exposed on a multicollimator camera calibrator using a white light source rated at approximately 5200K.

I. Calibrated Focal Length: ✓153.079 mm

II. Lens Distortion

Field angle:	7.5°	15°	22.7°	30°	35°	40°
Symmetric radial (um)	0	0	1	2	2	-2
Decentering (um)	0	0	0	1	1	2

Symmetric radial distortion parameters	Decentering distortion parameters	Calibrated principal point
$K_0 = 0.1099 \times 10^{-5}$	$P_1 = -0.6669 \times 10^{-7}$	$x_p = 0.003$ mm
$K_1 = -0.7708 \times 10^{-8}$	$P_2 = 0.9810 \times 10^{-7}$	$y_p = -0.006$ mm
$K_2 = 0.4744 \times 10^{-12}$	$P_3 = 0.0000$	
$K_3 = 0.0000$	$P_4 = 0.0000$	
$K_4 = 0.0000$		

The values and parameters for Calibrated Focal Length (CFL), Symmetric Radial Distortion (K_0, K_1, K_2, K_3, K_4), Decentering Distortion (P_1, P_2, P_3, P_4), and Calibrated Principal Point [point of symmetry] (x_p, y_p) were determined through a least-squares Simultaneous Multiframe Analytical Calibration (SMAC) adjustment. The x and y-coordinate measurements utilized in the adjustment of the above parameters have a standard deviation (σ) of ±3 microns.

* Equipped with Forward Motion Compensation

(1 of 4)

III. Lens Resolving Power in cycles/mm

Area-weighted average resolution: 92

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	134	134	113	67	113	95	67
Tangential lines	134	113	95	80	95	95	80

The resolving power is obtained by photographing a series of test bars and examining the resultant image with appropriate magnification to find the spatial frequency of the finest pattern in which the bars can be counted with reasonable confidence. The series of patterns has spatial frequencies from 5 to 268 cycles/mm in a geometric series having a ratio of the 4th root of 2. Radial lines are parallel to a radius from the center of the field, and tangential lines are perpendicular to a radius.

IV. Filter Parallelism

The two surfaces of the Wild 525 No. 5347 filter accompanying this camera are within 10 seconds of being parallel. This filter was used for the calibration.

V. Shutter Calibration

Indicated time (sec)	Rise time (μ sec)	Fall Time (μ sec)	½ width time (ms)	Nom. Speed (sec.)	Efficiency (%)
1/125	1790	1758	8.02	1/140	87
1/250	929	912	4.28	1/270	87
1/500	468	460	2.15	1/540	87
1/1000	221	227	1.08	1/1060	87

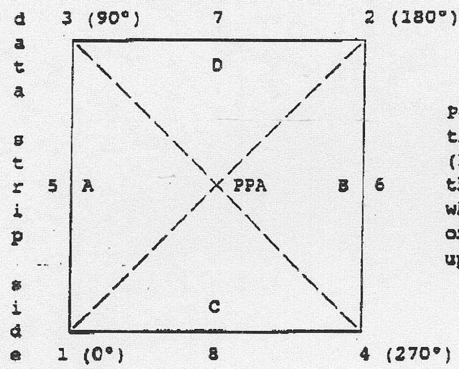
The effective exposure times were determined with the lens at aperture f/4. The method is considered accurate within 3 percent. The technique used is Method I described in American National Standard PH3.48-1972(R1978).

VI. Film Platen

The film platen mounted in Wild RC20 drive unit No. 5062-481 does not depart from a true plane by more than 13 um (0.0005 in).

This camera is equipped with a platen identification marker that will register "481" in the data strip area for each exposure.

VII. Principal Points and Fiducial Coordinates



Positions of all points are referenced to the principal point of autocollimation (PPA) as origin. The diagram indicates the orientation of the reference points when the camera is viewed from the back, or a contact positive with the emulsion up. The data strip is to the left.

	X coordinate	Y coordinate
Indicated principal point, corner fiducials	-0.001 mm	0.005 mm
Indicated principal point, midside fiducials	-0.001	0.000
Principal point of autocollimation (PPA)	0.0	0.0
Calibrated principal point (pt. of sym.) x_p, y_p	0.003	-0.006

Fiducial Marks		
1	-106.006 mm	-105.999 mm
2	105.994	105.998
3	-105.991	105.998
4	105.998	-105.999
5	-109.999	0.002
6	110.005	-0.002
7	0.004	110.001
8	-0.006	-110.004

VIII. Distances Between Fiducial Marks

Corner fiducials (diagonals)

1-2: 299.812 mm   3-4: 299.803 mm

Lines joining these markers intersect at an angle of 89° 59' 58"

Midside fiducials

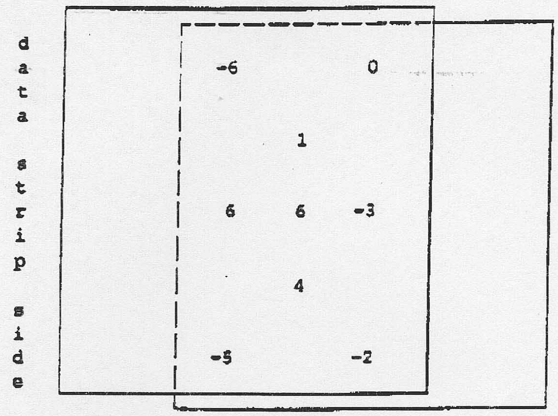
5-6: 220.004 mm   7-8: 220.005 mm

Lines joining these markers intersect at an angle of 89° 59' 54"

IX. Stereomodel Flatness

FMC Drive Unit No.: 5062-481 Base/Height ratio: 0.6

Platen ID: 481 Maximum angle of field tested: 40°



Stereomodel
Test point array
(values in micrometers)

The values shown on the diagram are the average departures from flatness (at negative scale) for two computer-simulated stereo models. The values are based on comparator measurements on contact glass (Kodak Micro-flat) diapositives made from Kodak 2405 film exposures. These measurements can vary by as much as ± 5 μm from model to model.

X. System Resolving Power on film in cycles/mm

Area-weighted average resolution: 43 Film: Type 2405

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	57	57	48	40	48	40	40
Tangential lines	57	57	48	40	40	40	40

This aerial mapping camera calibration report supersedes the previously issued USGS Report No. OSL/2348, dated August 13, 1997.

John J. Lenart
Chief, Technology Operations Section
National Mapping Division

APPENDIX K. Thematic Accuracy Data

Plot ID	Original Formation	Revised Formation	Type of Error	Reason for Error
3	I.A.8.N.b	II.A.4.N.a	Physiognomic class	Overestimation of crown cover
23	Cleared-Forestry	III.B.2.N.a	Interpreter error	Did not know power line easements
24	I.A.8.C.x	I.A.8.N.b	Physiognomic class	Mistook growth pattern for rows
32	I.B.2.N.d	I.B.2.N.a	Hydrologic period	Overestimation of wet area
34	I.C.3.N.a	I.A.8.N.b	Evergreen/deciduous confusion	Not mixed, but pure Virginia pine
35	I.B.2.N.d	I.B.2.N.a	Hydrologic period	Overestimation of wet area
38	I.A.8.C.x	I.A.8.N.b	Physiognomic class	Mistook growth pattern for rows
45	II.A.4.N.a	I.A.8.N.b	Physiognomic class	Underestimation of crown cover
49	I.B.2.N.d	I.B.2.N.a	Hydrologic period	Overestimation of wet area
67	III.A Evrg Shrub	I.A.8.N.b	Time-lapse disagreement	Due to time lapse between photos and accuracy assessment
68	I.A.8.N.b	II.C.3.N.a	Physiognomic class	Overestimation of crown cover and evergreen component
83	Agricultural Fields	III.B.2.N.a	Interpreter error	Did not know power line easements
84	I.A.8.N.b	I.A.8.C.x	Interpreter error	Did not recognize crop rows
103	III.A Evrg Shrub	I.A.8.N.b	Time-lapse disagreement	Due to time lapse between photos and accuracy assessment
106	I.B.2.N.e	I.B.2.N.a	Interpreter error	Incorrectly classed stand based on slope and species
112	II.C.3.N.a	I.B.2.N.d	Physiognomic class	Underestimation of crown cover and evergreen component
124	I.A.8.N.c	I.A.8.N.b	Physiognomic class	Mistook conical crowns for round
125	I.B.2.N.a	I.B.2.N.d	Hydrologic period	Underestimation of wet area
129	Disturbed	V.A.5.C.x	Interpreter error	Did not know power line easements
134	III.A Evrg Shrub	I.C.3.N.a	Time-lapse disagreement	Due to time lapse between photos and accuracy assessment
135	Cleared-Forestry	V.A.5.C.x	Interpreter error	Did not know power line easements
136	II.C.3.N.a	III.B.2.N.a	Physiognomic class	Overestimation of crown cover and evergreen component
142	Cleared-Forestry	V.A.5.C.x	Interpreter error	Did not know power line easements
145	III.A.2.N.a	III.B.2.N.a	Physiognomic class	Did not recognize majority of stand as deciduous
147	I.A.8.N.b	I.B.2.N.a	Physiognomic class	Did not recognize majority of stand as evergreen
148	I.C.3.N.a	I.A.8.C.x	Physiognomic class	Underestimation of evergreen component and did not recognize rows
153	I.A.8.N.b	II.A.4.N.a	Physiognomic class	Overestimation of crown cover
156	I.A.8.N.b	I.C.3.N.a	Physiognomic class	Overestimation of evergreen component

Plot ID	Original Formation	Revised Formation	Type of Error	Reason for Error
157	V.A.5.C.x	I.B.2.N.d	Interpreter error	Overstimated cover, point falls in field with spaced trees
163	Agricultural Fields	II.A.4.N.b	Time-lapse disagreement	Due to time lapse between photos and accuracy assessment
166	V.A.5.C.x	I.A.8.N.b	Interpreter error	Point fell on edge of two polygons, classified adjacent stand
167	I.A.8.C.x	I.A.8.N.b	Physiognomic class	Mistook growth pattern for rows
169	Agricultural Fields	I.A.8.N.c	Interpreter error	Point fell between two fields in small evergreen stand
185	I.C.3.N.a	I.A.8.N.b	Physiognomic class	Underestimation of evergreen component
186	Agricultural Fields	III.C.2.N.a	Interpreter error and time-lapse disagreement	Underestimation of cover, time-lapse between photos and accuracy assessment
193	III.A.2.N.a	II.B.2.N.b	Physiognomic class	Overestimation of crown cover and evergreen component
198	I.A.8.C.x	I.A.8.N.b	Physiognomic class	Mistook growth pattern for rows

APPENDIX L. Positional Accuracy Data

Positional Accuracy Calculations - Appomattox Courthouse NHP Formation Map

X_COORD_1	Y_COORD_fi	X_COORD_	Y_COORD_p	Xi - Xc	(Xi-Xc)2	Yi - Yc	(Yi-Yc)2	Euclidean Dist
693735.079	4137709.047	693734.916	4137710.701	0.163	0.026	1.654	2.737	1.662
695962.017	4140758.409	695962.430	4140758.416	0.413	0.171	0.007	0.000	0.413
695056.188	4141146.721	695056.042	4141146.614	0.146	0.021	0.107	0.012	0.181
696115.718	4140272.337	696116.548	4140271.958	0.830	0.689	0.379	0.144	0.912
694871.111	4140316.722	694871.334	4140316.144	0.223	0.050	0.578	0.335	0.620
696745.676	4141117.762	696745.535	4141118.316	0.141	0.020	0.554	0.307	0.572
696567.325	4140604.834	696567.764	4140606.604	0.439	0.193	1.770	3.132	1.824
696651.810	4140525.037	696651.323	4140525.703	0.487	0.237	0.666	0.443	0.825
696727.683	4140460.983	696726.231	4140465.200	1.452	2.109	4.217	17.779	4.460
696114.481	4140551.240	696114.452	4140551.308	0.029	0.001	0.068	0.005	0.074
695963.166	4140392.931	695962.286	4140391.908	0.880	0.775	1.023	1.046	1.349
696244.513	4140739.848	696242.943	4140739.446	1.570	2.466	0.402	0.162	1.621
695468.990	4140478.184	695467.373	4140479.459	1.617	2.616	1.275	1.625	2.059
695489.513	4139850.827	695489.176	4139851.202	0.337	0.113	0.375	0.141	0.504
695809.968	4139941.078	695808.706	4139938.146	1.262	1.593	2.932	8.594	3.192
695466.472	4139187.604	695465.504	4139186.821	0.968	0.938	0.783	0.614	1.246
695301.740	4139400.495	695300.352	4139400.779	1.388	1.926	0.284	0.081	1.417
695434.003	4139430.367	695434.006	4139431.725	0.003	0.000	1.358	1.845	1.358
694889.127	4138301.324	694888.855	4138303.238	0.272	0.074	1.914	3.662	1.933
693462.275	4138383.995	693461.641	4138385.541	0.634	0.401	1.546	2.389	1.671
695384.887	4139095.569	695384.367	4139094.586	0.520	0.271	0.983	0.967	1.112
695396.392	4138805.702	695396.858	4138805.926	0.466	0.217	0.224	0.050	0.517
695112.590	4138919.358	695111.446	4138919.768	1.144	1.309	0.410	0.168	1.215
695002.680	4139101.318	695002.337	4139103.416	0.343	0.118	2.098	4.400	2.126
692708.760	4139283.381	692709.571	4139284.286	0.811	0.658	0.905	0.819	1.215
695395.468	4140879.492	695395.089	4140879.587	0.379	0.144	0.095	0.009	0.391
692821.328	4137971.071	692822.249	4137971.609	0.921	0.848	0.538	0.289	1.066
692929.670	4138355.729	692929.520	4138355.419	0.150	0.023	0.310	0.096	0.345
693092.317	4138428.154	693093.185	4138427.949	0.868	0.753	0.205	0.042	0.892
696317.382	4138203.269	696316.111	4138205.762	1.271	1.616	2.493	6.215	2.798
695317.322	4137256.329	695317.811	4137258.555	0.489	0.239	2.226	4.954	2.279
695784.825	4139691.864	695784.183	4139692.765	0.642	0.413	0.901	0.811	1.106
695620.279	4139689.548	695620.392	4139691.197	0.113	0.013	1.649	2.718	1.652
695591.805	4139719.045	695591.184	4139721.197	0.621	0.386	2.152	4.630	2.240
695040.947	4138704.538	695040.542	4138706.686	0.405	0.164	2.148	4.614	2.186
694304.499	4138780.043	694303.801	4138782.086	0.698	0.487	2.043	4.174	2.159
694535.386	4138732.300	694535.629	4138733.835	0.243	0.059	1.535	2.356	1.554
694469.030	4139373.856	694468.245	4139377.084	0.785	0.617	3.228	10.419	3.322
694706.756	4139345.503	694705.880	4139346.697	0.876	0.767	1.194	1.426	1.481
			sum		23.517		94.208	57.547
			N		39.000		39.000	39.000
			RMSE(m)	**x =**	**0.603**	**y =**	**2.416**	
						Avg Euclidean Di		**1.476 meters**

APPENDIX M. Preliminary Formation and Alliance List for the ACHNHP Mapping Project

Composed by Melani Harrell, NCSU CEO, and Dr. Richard Braham, NCSU Forestry; revised by Gary Fleming, Virginia NHP.

Formation	Alliances
I.A.8.C.x -	Planted/cultivated temperate or subpolar needle-leaved evergreen forest
	PINUS TAEDA PLANTED FOREST ALLIANCE
	PINUS VIRGINIANA PLANTED FOREST ALLIANCE
I.A.8.N.b -	Rounded-crowned temperate or subpolar needle-leaved evergreen forest
	PINUS TAEDA - PINUS ECHINATA FOREST ALLIANCE
	PINUS VIRGINIANA FOREST ALLIANCE
I.A.8.N.c -	Conical-crowned temperate or subpolar needle-leaved evergreen
	JUNIPERUS VIRGINIANA FOREST ALLIANCE
I.B.2.N.a -	Lowland or submontane cold-deciduous forest
	AILANTHUS ALTISSIMA FOREST ALLIANCE
	FAGUS GRANDIFOLIA - QUERCUS ALBA FOREST ALLIANCE
	FAGUS GRANDIFOLIA - QUERCUS RUBRA - QUERCUS ALBA FOREST ALLIANCE
	LIQUIDAMBAR STYRACIFLUA FOREST ALLIANCE
	LIRIODENDRON TULIPIFERA FOREST ALLIANCE
	QUERCUS ALBA - (QUERCUS RUBRA, CARYA SPP.) FOREST ALLIANCE
	QUERCUS ALBA - QUERCUS (FALCATA, STELLATA) FOREST ALLIANCE
	QUERCUS PRINUS - (QUERCUS COCCINEA, QUERCUS VELUTINA) FOREST ALLIANCE
	QUERCUS PRINUS - QUERCUS (ALBA, FALCATA, RUBRA, VELUTINA) FOREST ALLIANCE
	QUERCUS STELLATA - QUERCUS MARILANDICA FOREST ALLIANCE
	QUERCUS VELUTINA - QUERCUS ALBA - (QUERCUS COCCINEA) FOREST ALLIANCE
	ROBINIA PSEUDOACACIA FOREST ALLIANCE
I.B.2.N.d -	Temporarily flooded cold-deciduous forest
	ACER NEGUNDO TEMPORARILY FLOODED FOREST ALLIANCE
	ACER SACCHARINUM TEMPORARILY FLOODED FOREST ALLIANCE
	BETULA NIGRA - (PLATANUS OCCIDENTALIS) TEMPORARILY FLOODED FOREST ALLIANCE
	FAGUS GRANDIFOLIA TEMPORARILY FLOODED FOREST ALLIANCE
	FRAXINUS PENNSYLVANICA - ULMUS AMERICANA - CELTIS (OCCIDENTALIS, LAEVIGATA) TEMP. FLOODED FOREST ALL.
	LIQUIDAMBAR STYRACIFLUA - (LIRIODENDRON TULIPIFERA, ACER RUBRUM) TEMP. FLOODED FOREST ALL.
	PLATANUS OCCIDENTALIS - (FRAXINUS PENNSYLVANICA, CELTIS LAEVIGATA, ACER SACCHARINUM) TEMP. FLOODED FOREST ALL.
	PLATANUS OCCIDENTALIS - (LIQUIDAMBAR STYRACIFLUA, LIRIODENDRON TULIPIFERA) TEMP. FLOODED FOREST ALL.
	POPULUS DELTOIDES TEMPORARILY FLOODED FOREST ALLIANCE

Formation	Alliances (continuted)
(I.B.2.N.e)	QUERCUS (MICHAUXII, PAGODA, SHUMARDII) - LIQUIDAMBAR STYRACIFLUA TEMP. FLOODED FOREST ALL.
	QUERCUS PALUSTRIS - ACER RUBRUM TEMPORARILY FLOODED FOREST ALLIANCE
	SALIX NIGRA TEMPORARILY FLOODED FOREST ALLIANCE
I.B.2.N.e -	Seasonally flooded cold-deciduous forest
	ACER RUBRUM - FRAXINUS PENNSYLVANICA SEASONALLY FLOODED FOREST ALLIANCE
	LIQUIDAMBAR STYRACIFLUA - (ACER RUBRUM) SEASONALLY FLOODED FOREST ALLIANCE
	QUERCUS PALUSTRIS - (QUERCUS BICOLOR) SEASONALLY FLOODED FOREST ALLIANCE
	QUERCUS PHELLOS SEASONALLY FLOODED FOREST ALLIANCE
	SALIX NIGRA SEASONALLY FLOODED FOREST ALLIANCE
I.B.2.N.g -	Saturated cold-deciduous forest
	ACER RUBRUM - NYSSA SYLVATICA SATURATED FOREST ALLIANCE
	NYSSA BIFLORA - ACER RUBRUM - (LIRIODENDRON TULIPIFERA) SATURATED FOREST ALLIANCE
	QUERCUS LAURIFOLIA - NYSSA BIFLORA SATURATED FOREST ALLIANCE
I.C.3.N.a -	Mixed needle-leaved evergreen - cold-deciduous forest
	JUNIPERUS VIRGINIANA - QUERCUS (STELLATA, VELUTINA, MARILANDICA) FOREST ALLIANCE
	PINUS ECHINATA - QUERCUS (ALBA, FALCATA, STELLATA, VELUTINA) FOREST ALLIANCE
	PINUS TAEDA - (LIQUIDAMBAR STYRACIFLUA, LIRIODENDRON TULIPIFERA) FOREST ALLIANCE
	PINUS TAEDA - QUERCUS (ALBA, FALCATA, STELLATA) FOREST ALLIANCE
II.B.2.N.a -	Cold-deciduous woodland
	FRAXINUS AMERICANA - CARYA GLABRA - (JUNIPERUS VIRGINIANA) WOODLAND ALLIANCE
	PAULOWNIA TOMENTOSA WOODLAND ALLIANCE
	QUERCUS ALBA - QUERCUS STELLATA - QUERCUS VELUTINA - (QUERCUS FALCATA) WOODLAND ALL.
II.B.2.N.b -	Temporarily flooded cold-deciduous woodland
	PLATANUS OCCIDENTALIS - (BETULA NIGRA, SALIX SPP.) TEMPORARILY FLOODED WOODLAND ALLIANCE
II.C.3.N.a -	Mixed needle-leaved evergreen - cold-deciduous woodland
	PINUS (RIGIDA, PUNGENS, VIRGINIANA) - QUERCUS PRINUS WOODLAND ALLIANCE
	PINUS ECHINATA - QUERCUS (ALBA, FALCATA, STELLATA, VELUTINA) WOODLAND ALLIANCE
III.A.2.N.a -	Temperate broad-leaved evergreen shrubland
	LIGUSTRUM SINENSE SHRUBLAND ALLIANCE
III.A.2.N.g -	Temporarily flooded temperate broad-leaved evergreen shrubland
	LIGUSTRUM SINENSE TEMPORARILY FLOODED SHRUBLAND ALLIANCE

APPENDIX N. USGS-NPS Vegetation Mapping Program Accuracy Assessment Form

1. Plot Number ____________ 2. Park Code ____________ 3. Date ____________

4. Observer(s) ______________________________ 5. Datum ________ 6. Accuracy ________

7. UTM Coordinates: Easting _ _ _, _ _ _ Northing _, _ _ _, _ _ _

8. UTM Zone ________ 9. Offset from Point: Easting ________ m Northing ________ m

10. Topographic Description ______________________________

11. Elevation ____________ m 12. Aspect ____________

13. Veg Assoc. at Site ______________________________

14. Veg Assoc 2 within 50m of Site ______________________________

15. Veg Assoc 3 within 50m of Site ______________________________

16. Major Species Present (by strata) ______________________________

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17. Canopy Closure of Top Layer ____________

18. Rationale for Classification ______________________________

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19. Comments ______________________________

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